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TRANSACTIONS OF THE

American Foundrymen's Association

Proceedings of the

Twenty-fifth Annual Meeting

COLUMBUS, O.

October 4 to 8, 1920

VOLUME XXIX

Edited by

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Summary of the Proceedings of the Twenty-fifth Annual Meeting

Columbus, O., Oct. 4 to 8, 1920

A record-breaking attendance, unusual interest in the technical program, an unparalleled display of foundry and metalworking supplies and equipment, and an enthusiastic and generous response to the need for research in foundry work were the outstanding features of the twenty-fifth annual convention of the American Foundrymen's association at Columbus.

Several departures from the usual plan of meetings, which were tried out for the first time, met with gratifying success. The holding of meetings and exhibition in adjacent buildings elicited general approval and enabled many foundrymen to fully enjoy all features of the convention with little if any inconvenience.

The program differed from that of previous conventions in that the opening session was devoted exclusively to technical papers and committee reports, the usual business session being incorporated with a smoker held Thursday evening. The newly formed nonferrous section of the association held two joint sessions with the Institute of Metals division of the American Institute of Mining and Metallurgical Engineers. Papers for these sessions were presented by representatives of both organizations and the success of the arrangement was evidenced by the interest shown and the discussion following the presentation of each paper.

For the first time in the history of the association two sessions were devoted exclusively to papers and discussion on the timely subject of industrial relations. The program included the names of nationally known authorities on the many phases of the problems arising between employer and employe.

One of the most encouraging features of the meeting was the tendency toward more thorough discussion of papers. A greater number of foundrymen participated in the discussions than at any previous meeting. The program was an extensive one, including 51 papers and eight committee reports.

In an effort to enable every foundryman to attend all the sessions in which he might be interested, the program was arranged so that not more than two meetings were held simultaneously. A session on gray iron and general topics was held Tuesday morning; simultaneous sessions on steel and nonferrous practice Tuesday afternoon and Wednesday morning; single sessions on industrial relations Wednesday afternoon and Thursday morning; and simultaneous sessions on malleable iron and general topics Friday morning.

Opening Session

Tuesday, Oct. 5, 9 a. m.

C. S. Koch, president, American Foundrymen's Association, presided. The following papers and reports were presented and discussed:

"Zirconium in Cast Iron," by Richard Moldenke, Watchung, N. J.

"The Foundry of the U. S. S. Prometheus, Repair Ship of the Atlantic Fleet," by Lieut. R. F. Nourse, United States Navy.

"A Note on the Electric Furnace and the Problem of Sulphur in Cast Iron," by George K. Elliot, Lunkenheimer Co., Cincinnati.

"Making High Grade Iron for Milling Machine Tables," by Leroy Sherwin, Brown & Sharpe Mfg. Co., Providence, R. I.

"Standardizing Gray Iron Samples for Analytical Determination," by E. J. Fowler, Pacific Foundry Co., San Francisco, Cal.

"Electrical Apparatus in a Modern Iron Foundry," by F. D. Egan, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

"Foundry Methods and Equipment for Producing Machine Tool Castings," by A. N. Kelley, Modern Foundry Co., Cincinnati.

Report of the A. F. A. Committee Advisory to the U. S. Bureau of Standards, by Richard Moldenke, Watchung, N. J.

Report of A. F. A. Committee on Specifications for Gray Iron Castings, by Richard Moldenke, Watchung, N. J.

By vote of those in attendance, it was decided to hold an extra session on gray iron. Tuesday afternoon, Dr. Richard Moldenke to preside as chairman.

Steel Session

Tuesday, Oct. 5, 2 p. m.

Past President R. A. Bull, Sewickly, Pa., presided as chairman. The following papers and reports were presented and discussed:

"Obtaining Molding Materials for the Steel Foundry," by R. L. Lindstrom, Canadian Car & Foundry, Montreal, Can.

"Standardizing the Design and Construction of Patterns for Small Steel Castings," by K. V. Wheeler, Lebanon Steel Foundry, Lebanon, Pa.

In the discussion of this paper it was moved, seconded and carried that the subject of standardizing patterns be placed within the scope of the activities of the standing committee on steel foundry standards. This motion was subsequently amended to recommend to the board of directors that the problem of standardizing of patterns be placed in the hands of a special committee, to pursue the work vigorously, undertaking such expenses as may be deemed advisable by the board. The following papers were presented:

"Some Details in the Molding of Small Steel Castings," by R. J. Doty, Sivyer Steel Casting Co., Milwaukee.

"Pouring, Gating and Feeding Steel Castings," by R. B. Farquhar, Electric Steel Co. of Indiana, Indianapolis, Ind.

W. A. Janssen, American Steel Foundries, after stating that the A. F. A. Committee on Steel Foundry Standards had no report to submit, emphasized the need of follow-up work on committee reports and standards. Following some discus-

sion of the subject, those present assented to the chairman's suggestion that the proposition as developed in the discussion be brought to the attention of the board of directors.

While A. W. Gregg, Whiting Corp., Harvey, Ill:, acted as chairman, R. A. Bull presented the report of the A. F. A. Committee on Specifications for Steel Castings to co-operate with the American Society for Testing Materials and the report of the A. F. A. Representative on the joint Committee on Investigation of Phosphorus and Sulphur in Steel.

A paper entitled, "A Novel Core Oven," was presented by Stephen B. Phelps, Jones & Laughlin Steel Co., Pittsburgh.

Joint Meeting of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers and the Nonferrous Section of the American Foundrymen's Association

Tuesday, Oct. 5, 2 p. m.

William H. Bassett, president of the Institute of Metals division of the A. I. M. M. E., acted as chairman. The following papers were presented and discussed:

"Investigation of Brass Foundry Fluxes," by C. W. Hill, T. B. Thomas and W. B. Vietz.

"Laboratory Testing of Sands, Cores and Core Binders," by F. L. Wolf and A. A. Grubb.

"The Reclamation of Metal from Brass Foundry Refuse," by F. L. Wolf and G. E. Alderson.

"A New Process for Making 15 per cent Phosphor Copper," by P. E. Denmler.

"The Relation of Die Casting to Foundry Practice," by Charles Pack, Doehler Die Casting Co., Brooklyn, N. Y.

"The Solubility of Hydrogen in Molten Copper and Copper Alloys," by C. W. Hill, T. P. Thomas and G. P. Luckey.

"Carborundum Refractories in Nonferrous Metallurgy," by Dr. M. L. Hartman, Carborundum Co., Niagara Falls, N. Y.

Joint Meeting of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers and the Nonferrous Section of the American Foundrymen's Association

Wednesday, Oct. 6, 9:30 *a. m.*

G. H. Clamer, past president of the Institute of Metals, presided. The following papers were presented and discussed:

"Casting Losses in the Aluminum Foundry," by Robert J. Anderson, Bureau of Mines, Pittsburgh.

"Coke and By-Products as Fuels for Metals Melting," by F. W. Sperr Jr.

"A New Electric Furnace for Melting Brass," by C. H. Booth, Booth Electric Furnace Co., Chicago.

"Status of the Electric Furnace in Nonferrous Industry," by E. F. Cone, *The Iron Age,* New York.

"Pouring Temperatures as Affecting Casting Shrinkage and Solidity," by Russell R. Clarke.

"Producing Small Nonferrous Castings," by Raymond H. Sullivan, Yale & Towne Mfg. Co., Stamford, Conn.

Steel Session

Wednesday, Oct. 6, 9:30 *a. m.*

President C. S. Koch presided and the following papers and reports were presented and discussed:

"Annealing Steel With Pulverized Coal," by C. H. Gale, Pressed Steel Car Co., McKees Rocks, Pa.

"Steel Foundry Finishing Department Practice," by A. W. Gregg, Whiting Foundry Equipment Co., Chicago.

"Electric Heat Treating of Steel Castings," by E. F. Collins, General Electric Co., Schenectady, N. Y.

"Heat Treating of Steel Tractor Castings," by Fred Grotts, Holt Mfg. Co., Peoria, Ill.

"Acid Electric Steelmaking," by James W. Galvin, and Charles N. Ring, Ohio Steel Foundry Co., Springfield, O.

"Making Steel Castings to Specifications," by E. R. Young Detroit Steel Castings Co., Detroit, Mich.

Industrial Relations Session

Wednesday, Oct. 6, 2:00 p. m.

Arthur H. Young, International Harvester Co., Chicago, presided as chairman. The following papers were presented and discussed:

"Industrial Relationships Between Employer and Employe," by Meyer Bloomfield, *Industrial Relations,* Boston, Mass.

"Training Foundry Executives," by R. E. Kennedy and Bruce W. Benedict, University of Illinois, Urbana, Ill.

"The Foreman's Relationship to the Worker," by Charles Prosser, Dunwoody Institute, Minneapolis, Minn.

"Americanization," by John R. Dyer, Y. M. C. A. New York.

"The One Best Way to Do Work in the Foundry," by Frank B. Gilbreth and L. M. Gilbreth, Frank B. Gilbreth, Inc., Montclair, N. J.

Following the discussion on the paper, "Training Foundry Executives," Mr. A. O. Backert, Cleveland, moved that the board of directors be petitioned to appoint a committee to make an investigation of existing agencies or schools that are undertaking the training of executives, and that this committee be empowered at the discretion of the board to solicit funds for that purpose. The motion was seconded and carried.

Industrial Relations Session

Thursday, Oct. 7, 9:30 a. m.

Dr. C. B. Connelley, Department of Labor and Industry, State of Pennsylvania, Harrisburg, Pa., presided as chairman. The following papers and reports were read and discussed:

"Developing the Foreman," by M. C. Evans, International Harvester Co., Chicago.

"The Right Man on the Right Job," by Arthur H. Young, International Harvester Co., Chicago.

"Employment Problems," by Ralph M. Wells, Employment Managers' Association, 6 Beacon St., Boston, Mass.

"Industrial Relations Departments," by James W. Brown, Chain Belt Co., Milwaukee.

"Various Plans of Industrial Relations," by Ray Vance, Brookmire Economic Service, Inc., New York.

Report of A. F. A. Committee on Industrial Education and Training of Apprentices, by C. B. Connelley, *Chairman,* Department of Labor and Industry, Harrisburg, Pa.

Malleable Iron Session

Friday, Oct. 8, 9:30 *a. m.*

W. R. Bean, vice president of the association, presided. The following reports and papers were presented and discussed:

"The Triplex Process of Making Electric Furnace Malleable," by H. A. Schwartz, National Malleable Castings Co., Cleveland.

"Notes on Malleable Iron," by Enrique Touceda, Albany, N. Y.

"Fractures and Microstructures of American Malleable Cast Iron," by W. R. Bean, H. W. Highriter and E. S. Davenport, Eastern Malleable Iron Co., Naugatuck, Conn.

"A New Research Department for a Large Malleable Plant," by H. A. Schwartz, National Malleable Castings Co., Cleveland.

"Fuel and Combustion," by Max Sklovsky, Deere & Co., Moline, Ill.

"Arc Welding and Cutting for the Foundry," by A. M. Candy, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

"Cutting Cast Iron With the Oxyacetylene Torch," by A S. Kinsey, Stevens Institute of Technology, Hoboken, N. J.

Report of A. F. A. Committee on Specifications for Malleable Iron Castings, by Enrique Touceda, *Chairman,* Albany, N. Y.

General Session

Friday, Oct. 8, 9:30 a. m.

C. R. Messinger, member of board of directors, American Foundrymen's Association, presided as chairman. The following papers and reports were presented and discussed:

"The Care of Foundry Equipment," by David McLain, McLain's System, Milwaukee.

"Important Considerations in the Design of Modern Foundries," by J. H. Hopp, Charles C. Kawin Co., Chicago.

"High-Level Illumination as Means of Increasing Foundry Production," by James Brake, Jr., Commonwealth Edison Co., Chicago.

"The Equipment of the Foundry—Today and in the Near Future," by A. R. Atwater, Osborn Mfg. Co., Cleveland.

"Notes on European Molding Machines," by H. Cole Estep, *The Foundry*, London, Eng.

"Foundry Engineering," by Frank D. Chase, Frank D. Chase, Inc., Chicago.

"Concrete Molding Floors," by Lieut. Col. H. C. Boyden, Portland Cement Association, Chicago.

Report of A. F. A. Committee on Specifications for Foundry Scrap, by J. G. Garrard, *Chairman*, Northwestern Malleable Iron Co., Milwaukee.

"Status of Electric Furnace in Steel Foundry Industry," by E. F. Cone, *The Iron Age*, New York.

Report of A. F. A. Committee on Safety, Sanitation and Fire Prevention, by Benjamin D. Fuller, *Chairman*, Defiance Paper Co., Niagara Falls, N. Y.

Annual Banquet

Wednesday, Oct. 6, 7 p. m., Hotel Deshler

C. S. Koch, president of the American Foundrymen's Association, presided as toastmaster. The president announced the offer of endowments of $5000 each from John A. Penton, J. S. Seaman, J. F. Whiting and W. H. McFadden and $1000 from the S. Obermayer Co., the details of which are given in the reports of the board of directors and the secretary-treasurer

in this volume. President Koch introduced Mr. Ford who presented a humorous after-dinner speech. Hon. Simeon Fess, member of the House of Representatives from Ohio, delivered an address in which he emphasized the need of retrenchment in the operation of the government.

Business Meeting and Smoker

Thursday, Oct. 7, 9 p. m.

C. S. Koch, who presided, read the annual address of the president, which appears on page 1 of this volume. Dr. R. M. Little, American Institute of Safety, New York, delivered a brief address on "Americanism."

The report of the committee on resolutions was presented by A. E. Howell, chairman, and unanimously adopted. The report includes the following relative to communications with the Institute of British Foundrymen.

"Your officers have received a communication from the secretary of the Institute of British Foundrymen, extending their greetings and sincere good wishes for the success of our convention. Your committee recommends that a letter such as the one attached, be sent in reply, by the officers of this association, and that a hearty invitation be extended to the British foundrymen to attend our next convention."

Thomas W. Pangborn, announced for himself and for his brother John C. Pangborn a gift to the association of $2500, which is covered in detail in the report of the board of directors in this volume.

The business session adjourned until Friday noon, at which time President Koch announced the result of the election of new officers as follows: President, W. R. Bean; vice president, C. R. Messinger; secretary-treasurer and manager of exhibits, C. E. Hoyt. The new officers made appropriate remarks and Mr. Hoyt presented a progressive report of the activities of the association.

With R. A. Bull as temporary chairman, C. S. Koch was unanimously elected an honorary member of the American Foundrymen's association.

Entertainment Features

Under the direction of G. R. Kittle, general chairman of the Columbus local committee, and through the co-operation of local foundrymen with the entertainment committee, members and guests of the association were provided with a number of enjoyable entertainment features. Band concerts were held Monday and Tuesday afternoons at the exhibition, and on Thursday afternoon estimating contests for foundrymen were conducted. Many foundrymen visited the various golf links in Columbus during the week. Refreshments and entertainment were provided at the smoker held Thursday evening and dancing followed the annual banquet Wednesday. As usual, an extensive program was prepared for the ladies. Upon their arrival they were the recipients of flowers sent by the committee. On Wednesday the ladies were taken on an automobile ride to the Scioto Country club, where tea was served. Thursday evening they attended a theater party.

During the week, practically all of the industrial plants of Columbus were open to visiting foundrymen, and excursions were made to many of the foundries.

Transactions

of the

American Foundrymen's Association

Annual Address

Transactions
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American Foundrymen's Association

Annual Address
By the President, C. S. Koch

YOUR outgoing president, following the examples of his worthy predecessors, submits a reckoning of his stewardship. He renders this, fully realizing that without the hearty co-operation of directors, secretary, and committees, no president can achieve satisfactory results. Due credit is here given.

It is not the desire to encroach on the duties of the secretary by giving details which should by their nature appear in his report. It is well, however, to mention and possibly emphasize that during the past year the by-laws of the association have been altered in order that the members may choose not only the directors but the officers as well. Provision has been made for the selection of a nominating committee by the board of directors as a whole, and, further, machinery has been established by which a petition ticket can be placed in running directly by the members. These changes all tend toward democracy, and with these new provisions there should be a consistent tendency toward a greater participation of the members in the affairs of the association.

Your president is pleased to announce that the Transactions of the association have been indexed during the year. The great assistance that this will be should be evident to everyone, as all that has transpired on a given subject will be under that heading. This index we hoped to have to distribute before this convention, but the task has been a large one. It is now in the hands of the printer, and you will soon receive your copy through the mails.

In answer to what appeared to all to be an urgent need, and after much judicious discussion, there has been established a new section in the association, devoted to the interests of the nonferrous branch of the foundry industry.

As it appears to the directors, this in no way should interfere with the activities of the Institute of Metals, nor affect the relations of that body and our association, but rather be of assistance in aiding the progress which has been made in that rapidly growing branch of our industry.

A report of the committee on standards of safety, sanitation and fire prevention has already been made, but it is quite proper to mention the matter here, as it is indicative of what your association can do for you.

That a safety code, a sanitation code, or any other code should be quite practical is beyond discussion. That such codes for the various states should be identical seems to be advantageous. Accordingly, our machinery being in operation, it was no task to respond to the request of the United States Bureau of Standards to do our part in sponsoring these federal codes. Without such machinery, it is not likely that we would have had much say regarding their contents, or have been able to materially assist the Bureau of Standards in its work.

During the past year, particularly through the efforts of your Past President, R. A. Bull, your association has a representative on the committee, fathered by the United States Bureau of Standards, which is making an exhaustive study of the effect of phosphorus and sulphur on the qualities of steel in whatever form used. This question is not only of more or less direct importance to many members, but is a serious economic matter to the country at large. The matter of sulphur is wrapped up very closely with the fuel supply, and no further delay should exist in determining the maximum sulphur content allowable in order to use the fuel resources of this country to best advantage. Many members of this association who produce steel castings will be called upon to assist the committee by giving data as to results

of tests, and the content of sulphur and phosphorus of steel parts which have either failed in service, or given unusual long life. The United States Bureau of Standards will no doubt sponsor many other investigations in the near future, and to have established closer relations with it indicates progress.

This association is also now represented on sub-committee of Committee A-1 of the American Society for Testing Materials, which sub-committee deals with the specifications of steel castings.

Reference to the program of this convention gives only a meager idea of the number of committees of this association. It is granted that some are not necessarily active each year. but it is well to have provided the means for quick action whenever need arises. That the interests of foundrymen can be thus guarded is not the main reason for the existence of some of these committees, but rather the assistance which can be given, when needed to promote the general welfare.

Another event of the year which surely should be mentioned here is the donation of funds by various individuals to become endowments, the proceeds of which are to be devoted to awards for work of merit pertaining to the development of our industry. These are most assuredly an indication not only of the increased interest taken in such matters by men of affairs, but also of the stability of this association. The donations referred to are: $5000 by John A. Penton, $5000 by J. S. Seaman, $5000 by J. H. Whiting, $5000 by William H. McFadden and $1000 by S. Obermayer Co.

Leaving more particularly the technical branch, and referring to the exhibition features, you should all be able to judge from the size and quality of this year's exhibit, as to the progress and status. Your manager of exhibits will report in detail. It may be appropriate to remark, however, that each year the difficulty of obtaining proper housing for the exhibit grows rapidly. If it be the desire of the association to have this feature continue to grow, it may be necessary to radically alter the basic ideas and principles which

have been in existence for the past years. A change each year geographically in the location of the convention seems desirable from many standpoints. A restriction of the lines represented by the exhibitors appears impossible. Rather, each year has been seen the beneficial effect due to the extension of the lines.

A reduction in the number of exhibitors would be regrettable. Less space allotted to each exhibitor is not practical. A great problem, therefore, is before the future officers and directors. The situation has been noted by your present board of directors, many of whom will serve again next year, and you may be sure that the interests of the association and the exhibitors will be carefully guarded.

It may be of interest to note that during the past few years of exceptional activity along political and social lines, your association has taken no active part as leaders in such matters. Your present officers and directors believe that such cannot be done without the risk of losing the technical character of the association.

Only one or two phases of the status of the association can be said to be regrettable:

First—This association, the only strictly technical group devoted to our industry, has only 1600 members. There exist about 6000 foundries in the country. This is not as it should be. If the number were greater, the activities could be extended. The matter of a service department for our association is being investigated by a special committee at the present time. The lack of funds may be a restraining factor in progressing with this work.

Secondly—The amount of discussion which takes place after the reading of a paper has been, generally speaking, too meager. You are all aware that many times such discussion brings out most vital and interesting points. No more can be said here than to urge the members to greater activities along these lines, and it is with pleasure that your president notes the improvement in this matter at this convention.

It has been customary for your president to refer in his annual address to the prevailing conditions, and to what appears to be the tendency of the times for the immediate future. This has been done, not always for the purpose of bringing something new to the members, or something of which all are not aware, but rather to record in the Transactions the ever changing conditions which take place in this country of ours. At the time of the annual meeting two years ago, the need was to throw all our energies to the production of necessary war materials. Last year, the keynote was increased production. At this particular time, it is somewhat hazardous to make any very definite statement, but perhaps we will not go far wrong, if for the very immediate future at least, we turn our energies as individuals, and as an association, to the subject of industrial relations.

During the early days of the life of this association, some twenty years ago, the minds of many of the leaders in the industry were turned toward such technical subjects as the silicon content of pig iron, and the proper mixtures chemically for our cupolas. Wherever foundrymen congregated, such subjects were in the limelight. In the minds of many, these matters were then hazy—were not well defined. However, many of them are now clarified until they have become as the A. B. C. of our industry, and so probably it would be well if the same energy as was applied to those strictly scientific considerations in those days were shifted to the now equally baffling subject of industrial relations.

This general term covers much. It runs all the way from the methods employed by your straw-bosses in the handling of the most unskilled men, to the subject of the division of profits and of representation of the men on our directing boards. Accordingly, it seems appropriate to your president, after a consideration of the existing problems, to emphasize the need to transfer our main energies for the immediate future from those matters, pertaining to the more material side of our industry, to those applying to the people who work with and for us.

In conclusion, it is the belief of the speaker that you have a much stronger association than you realize, and from his recent work in the association, it is the firm conviction that the American Foundrymen's association is a much greater power, and has vaster opportunities, than its members, yes perhaps its officers and directors, have realized.

There are problems soon to be met, but if you have members on your directorate, equal in capacity and willingness to act to the directors of the past year, then these matters will be properly solved. To have served with your directors and your secretary has been a pleasure, not a task.

Annual Report of the Board of Directors

To the Members of the American Foundrymen's Association, Inc.

Heretofore the annual report of the board of directors, submitted at the annual meeting of the association, has been for the year ending June 30, but with the revision of the by-laws adopted Jan. 13, 1920, the fiscal year now ends Dec. 31.

The revised by-laws also provide that an annual meeting of the board of directors shall be held the first Tuesday after the first Monday in December of each year, at which time the officers and directors elected at the preceding annual meeting of the association shall take office, and the annual reports of the board hereafter, will be for the period ending on that date.

The following report covers the period from Oct. 2, 1919, to Dec. 7, 1920, and contains the minutes of four meetings of the board, one meeting of the executive committee, one meeting of the committee on exhibits, and the annual reports of the manager for both the 1919 exhibit in Philadelphia, and the 1920 exhibit at Columbus.

The first meeting of the board was held at Philadelphia, Oct. 2, immediately following the annual meeting of the association, at which time directors were elected for the ensuing year. This board organized by electing C. S. Koch president, W. R. Bean, vice president, and C. E. Hoyt, secretary-treasurer of the association and manager of exhibits.

On Dec. 9 a meeting of the executive committee was held in Pittsburgh, at which time important matters of policy were considered, preliminary to a meeting of the board of directors. A committee on the revision of by-laws was appointed, and another committee on the place for the 1920 convention.

A second meeting of the board was held in Cleveland, Jan. 13. The special committee on revision of by-laws re-

ported, recommending a number of changes. The most important of these adopted by the board, provided for a change in the fiscal year from June 30 to Dec. 31, for the election of president, vice president, and directors by letter ballot of the members, and the dropping of the associate memberships.

It was voted that the revised by-laws become effective at once, and printed copy was promptly mailed to each member of the association.

The report of the manager of exhibits for the 1919 exhibit at Philadelphia was received, and is printed with the minutes of this meeting.

The committee on the place of convention reported, and Columbus was unanimously chosen as the place of the annual convention, the week of Oct. 4 to 8.

On April 28 a meeting of the committee on exhibits, the committee on promotion and membership, and the entertainment committee, was held in Columbus. The minutes of this meeting appear in chronological order in this report.

The third meeting of the board of directors was held at Columbus Athletic club, Columbus, O., Tuesday evening, Oct. 5, preceded by the annual dinner of officers, directors and members of the advisory board. This meeting was one of the most important ones in the history of the association. Four endowments of $5000.00 each were offered by the following members: John A. Penton, J. S. Seaman, J. H. Whiting, W. H. McFadden.

On the following day, another endowment of $1000.00 was offered by the S. Obermayer Co., and at the annual meeting on Thursday evening, Mr. Thomas W. Pangborn announced for himself and for his brother, John C. Pangborn, a gift to the association of $2500.00, to be used by the board at their discretion for research, or in other ways for the advancement of the foundry industry.

The fourth and last meeting of the board was held at Rochester, Tuesday, Dec. 7, 1920. The report of the manager of exhibits for the 1920 convention was received, and is appended to the minutes of this meeting.

The committee on awards, to whom the gifts or endow-

ments announced at the previous meeting of the board were referred, made a report, and formal resolutions for acceptance of each of the gifts were authorized.

A report of the committee on promotion and membership was received and the thanks of the association was formally expressed for the splendid work done by this committee.

A reading of the following report of the board will reveal the fact that this has been one of the most active and one of the most important years in the history of the association. A more detailed record of the activities of the technical department will be found in the annual report of the secretary-treasurer for the period ending Dec. 31, 1920.

Respectfully submitted,

C. E. HOYT, *Secretary.*

Minutes of Meetings of Board of Directors

Annual Meeting of the Board of Directors of the American Foundrymen's Association, Inc., Held at the Bellevue-Stratford Hotel, Philadelphia, Pa., Thursday, Oct. 2, 1912

Following the session of the annual meeting of the members of the American Foundrymen's Association held Thursday morning, Oct. 2, at which members of the board of directors were elected, a meeting of this board was held in the Association headquarters room, Bellevue-Stratford hotel, for the purpose of electing officers and transacting such other business as might be presented.

The secretary reported that at the annual meeting of the members, the following were elected directors of the American Foundrymen's Association, Inc., for the ensuing year, or until their successors are elected and qualified.

H. R. Atwater, Cleveland Osborn Mfg. Co., Cleveland.
A. O. Backert, Penton Publishing Co., Cleveland.
W. R. Bean, Eastern Malleable Iron Co., Naugatuck, Conn.
R. A. Bull, Sewickley, Pa.
H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
S. B. Chadsey, Massey-Harris Co., Ltd., Toronto, Ont., Can.
Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
C. E. Hoyt, American Foundrymen's Ass'n., Chicago.
W. A. Janssen, American Steel Foundries, Chicago.
S. T. Johnston, S. Obermayer Co., Chicago.
C. S. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.
C. R. Messinger, Sivyer Steel Casting Co., Milwaukee.
V. E. Minich, American Foundry Equipment Co., New York.
J. P. Pero, Missouri Malleable Iron Co., E. St. Louis, Ill.
A. B. Root Jr., Hunt-Spiller Corp., Boston.
J. Roy Tanner, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

The following members of the board were in attendance:

Messrs. C. S. Koch, W. R. Bean, C. E. Hoyt, H. R. Atwater, A. O. Backert, R. A. Bull, Alfred E. Howell, W. A. Janssen, S. T. Johnston, C. R. Messinger, V. E. Minich, J. P. Pero and A. B. Root Jr.

For the purpose of effecting an organization Mr. Howell nominated Mr. Backert as temporary chairman.

The chair announced that the first order of business would be the election of a president and that nominations were in order.

Mr. Minich nominated Mr. W. A. Janssen of the American Steel Foundries. Nomination seconded by Mr. Pero.

Mr. Janssen explained that the exactions of the position he had recently taken would prevent his giving the necessary time to the office of president of the association, and expressing his thanks for the honor proposed, he declined to let his nomination stand. It was accordingly withdrawn.

Mr. Bull then nominated Mr. C. S. Koch of the Fort Pitt Steel Casting Co. Nomination seconded by Mr. Howell. No other nom-

inations were presented, and on motion of Mr. Messinger, seconded by Mr. Bean, the nominations were closed and the secretary was instructed to cast the unanimous ballot of the directors for Mr. Koch, who was declared elected.

Mr. Koch was then escorted to the chair and made a brief speech of acceptance.

The chair announced that the next order of business would be the election of a vice president and that nominations were in order.

Mr. Bull nominated Mr. W. R. Bean of the Eastern Malleable Iron Co. Mr. Messinger, supporting the nomination, moved that the nominations be closed and that the secretary be instructed to cast the unanimous ballot of the directors for Mr. Bean as vice president, which motion was carried without dissent, and the chair declared Mr. Bean duly elected as vice president of the association.

The chair announced that the next order of business would be the election of a secretary. Mr. Backert moved that the offices of secretary and treasurer be combined for the ensuing year, as provided for in the by-laws. Motion prevailed.

Mr. Backert then nominated Mr. C. E. Hoyt for the office of secretary-treasurer of the association, and manager of the department of exhibits.

The nomination was seconded by Mr. Bull, who moved that the nominations be closed, and that the chair be instructed to cast the unanimous ballot of the directors for Mr. Hoyt as secretary-treasurer and manager of exhibits. Motion prevailed and the chair declared Mr. Hoyt elected as secretary-treasurer of the association and manager of the department of exhibits.

Mr. Minich moved that the salary of Mr. Hoyt as secretary-treasurer of the Association, dating from Oct. 1, 1919, be $200.00 per month, and that his salary as manager of the department of exhibits be $633.33 per month. The motion was supported by Mr. Backert and declared by President Koch as carried.

The election of officers being completed and the hour being late, it was moved that the meeting of the board be adjourned to meet at the call of the president. Motion prevailed.

Approved: Jan. 13, 1920.

A. O. BACKERT, President.
C. E. HOYT, Secretary.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE, AMERICAN FOUNDRYMEN'S ASSOCIATION, OLD COLONY CLUB ROOMS, PITTSBURGH, TUESDAY, DEC. 9, 1919.

This meeting was called by President C. S. Koch to consider important questions, some demanding immediate attention, and others consideration preparatory to presentation to the board of directors at a meeting to be held in Cleveland, Jan. 13, 1920.

Those present were President C. S. Koch, Vice President W. R. Bean, A. O. Backert, V. E. Minich, J. P. Pero and Secretary C. E. Hoyt.

The secretary read a report for the technical department as of date of Dec. 1, at which time the total book membership was 1233, of whom 1097 were active, 19 honorary and 117 associate. On Dec. 1

there were 93 members delinquent in payment of dues, 78 of whom were active and 15 associate.

The bank balance on Dec. 1 was $6,199.27, with the department of exhibits owing the technical department $430.00, as 50 per cent of the cost of sending out convention programs and literature prior to the Philadelphia meeting. Bills payable on Dec. 1, $94.13.

Reporting on cost work, the secretary stated that in accordance with the resolutions passed at the Philadelphia convention, the question of printing the cost system in the Bound Volume of Transactions had been submitted to all the subscribers to the cost system. The ballots returned were unanimous in favor of the plan recommended by the cost committee.

On motion duly seconded, it was voted that the cost system should be printed in Volume of Transactions No. 28.

A number of revisions in the by-laws were suggested, the principal ones being the change in the fiscal year from July 1 to Jan. 1, a change in the method of election of officers and directors, and dropping the associate membership feature.

It was moved by Mr. Backert and seconded by Mr. Bean that the president appoint a committee of three to draft revisions to the by-laws and submit a copy to each member of the board of directors by mail, prior to the next meeting of the board.

Motion prevailed and President Koch announced that Messrs. R. A. Bull, V. E. Minich and C. E. Hoyt would constitute the committee.

It was moved by Mr. Pero that in the make-up of committees for the ensuing year, it is the sentiment of the executive committee that the Foundry Supply Association and the Foundry Equipment Association should be represented on the exhibition committee through the respective presidents of these associations.

Motion seconded by Mr. Bean and carried.

The chair announced that the next order of business would be to consider invitations received for the 1920 convention and exhibit. Invitations from St. Louis, Chicago, Columbus and Cincinnati were read by the secretary.

Mr. Pero reported for St. Louis and said that he did not believe they had exhibit accommodations that would be adequate.

On invitation, Mr. Thomas Quinlan, manager of the publicity department of the Cincinnati Chamber of Commerce, personally presented Cincinnati's claims but it was found that they could not offer the necessary exhibit accommodations.

Communications received from Mr. John Y. Bassell, manager of the Columbus Convention and Publicity Association, offered ample exhibition accommodations on the Ohio State Fair Grounds free of rent, and assured that Columbus could provide first class hotel accommodations equal to taking care of the association's needs.

Following these reports the committee adjourned for luncheon where they were joined by Major R. A. Bull, who sat in with the committee during the session following lunch.

President Koch presented suggestions which had been made to him by Mr. Bull, looking toward some affiliation between the American Foundrymen's Association and local foundrymen's associations.

It was moved by Mr. Backert and seconded by Mr. Bean that Mr. Bull, with the assistance of the secretary, make a survey of local foundrymen's associations in various sections of the country and

ascertain to what extent the membership of locals was represented by membership in the A. F. A., and submit a report.

Major Bull suggested the publication of a monthly bulletin, and the secretary was instructed to submit to the president and members of the executive committee recommendations as to some form of bulletin or medium of communication with members in the interval between conventions.

Mr. Backert suggested a membership campaign, including "Foundrymen's Week," preceded by an extensive circularizing of the foundry field and organization of all sections of the country into districts with chairmen and sub-chairmen who would be expected to see that all foundrymen in their districts who are not members of the A. F. A. receive a personal invitation to join during "Foundrymen's Week."

On motion of Mr. Pero, seconded by Mr. Minich, Mr. Backert's suggestions were referred to the new committee on promotion and membership.

The secretary was instructed to investigate the cost of preparing and printing a complete cross index of all the volumes of Transactions of the association and if found advisable, to proceed with the work.

Returning again to the consideration of invitations for the 1920 Convention, President Koch announced that all invitations would be referred to a special committee consisting of the president, vice president, secretary, H. R. Atwater, S. T. Johnston and V. E. Minich, who would investigate conditions and report to the board of directors on Jan. 13,

Whereupon the meeting of the executive committee was adjourned to meet again at the call of the president.

C. S. Koch, President.
C. E. Hoyt, Secretary.

Meeting of the Board of Directors of the American Foundrymen's Association, Cleveland, Jan. 13, 1920.

The annual meeting of the board of directors of the American Foundrymen's Association was held at the Cleveland Athletic Club, beginning at 10:00 o'clock a. m.

Present: C. S. Koch, president; W. R. Bean, vice president; C. E. Hoyt, secretary-treasurer; H. R. Atwater, A. O. Backert, R. A. Bull, S. B. Chadsey, S. T. Johnston, C. R. Messinger, J. P. Pero A. B. Root Jr., and during part of the meeting, V. E. Minich.

The meeting was called to order by the president.

On motion, duly seconded and carried, the reading of the minutes of the annual meeting called for 12:00 o'clock the day prior to the last convention was waived.

Secretary Hoyt read the minutes of meeting held at Bellevue-Stratford hotel, Philadelphia, Thursday, Oct. 2, 1919.

On motion of Mr. Atwater, seconded by Mr. Hoyt, the minutes were approved.

On motion of Mr. Bull, seconded by Mr. Atwater, the reading of the minutes of meeting of the executive committee held in Pittsburgh Dec. 9, 1919, was waived.

The secretary then read a report on the condition of the association.

On motion of Mr. Bull, seconded by Mr. Messinger, the report was accepted.

Certain points in the report were then taken up for consideration and action.

On motion of Mr. Bean, seconded by Mr. Backert, the price of the Bound Volume was fixed at $6.00.

Mr. Bull moved that the audit of the cost account books suggested by the Secretary be made, together with a general audit by certified accountants later, and that the transfer of the funds be made as of Feb. 1, 1920. The motion was seconded by Mr. Atwater and carried.

The secretary read his report on the 1919 exhibit.

On motion of Mr. Root, seconded by Mr. Messinger, the report was accepted.

The question of raising the rates charged for floor space at exhibitions was discussed.

On motion of Mr. Backert, seconded by Mr. Johnston, the question of space rental was referred to the incoming exhibition committee, with power to act.

Moved by Mr. Backert and seconded by Mr. Messinger that "It is the sense of the board of directors of the American Foundrymen's Association that the exhibition committee, in fixing the space rental for next year have due regard for the action taken by the board or the sense of the board, that a surplus of at least $25,000 be raised, and that an increase of approximately 10 per cent be made in space rental next year."

Mr. Atwater moved to amend as follows: "That the exhibition committee take into consideration the expense of power, buildings, etc., and after looking over the situation shall, if it deems it necessary, raise the amount charged for space rental until it gives something for the fund."

The amendment was carried, and the motion as amended was put to a vote and carried.

The secretary then read the report of the committee appointed on next place of meeting, giving an account of the committee's visit to Columbus, O., and recommending that Columbus be selected as the place for the 1920 convention and exhibit.

Pending discussion of the report the board adjourned for luncheon, where they were joined by Mr. John Y. Bassell, manager the Columbus Convention and Publicity Association, and Dr. Wallick manager of the Deshler Hotel and President of the Columbus Hotel Men's Association.

President Koch called on these gentlemen, who enthusiastically put forth the advantages of meeting in Columbus, and Dr. Wallick guaranteed that the hotels that were members of the Columbus Hotel Men's Association would reserve at least 80 per cent of their total room capacity for the members and guests of the association.

Mr. Bassell and Dr. Wallick then retired, and following discussion it was moved by Mr. Johnston and seconded by Mr. Bean, that the invitation from Columbus be accepted and that the 1920 convention and exhibit be held in Columbus during the week of Oct. 4. Motion was unanimously carried.

Mr. Bull moved that the officers of the Association be authorized to enter into agreements with the proper authorities for the use of the grounds and buildings of the Ohio State Fair Ground, in accordance with the promises and assurances given by the gentlemen representing Columbus.

The President called for a report of the committee on revision of the by-laws, consisting of Mr. Bull, Mr. Minich and Mr. Hoyt. The report was presented by the chairman, Mr. Bull and considered article by article and section by section, and each section was adopted by motion as submitted or as amended.

At the close of the deliberations of the board on the report of the committee on by-laws it was moved by Vice President Bean, seconded by Mr. Pero, that the by-laws be adopted as a whole, as passed upon section by section, with the understanding that they should be referred back to the committee for such changes in phraseology as would make the intent of each section as clear as possible. Carried.

It was moved by Secretary Hoyt, seconded by Mr. Bull, that the by-laws as amended, become effective as of date of Jan. 13, 1920. Carried.

President Koch then announced that it would be proper now to proceed under the new by-laws and that first in order would be the election of a nominating committee.

Moved by Mr. Pero that a committee of three be appointed with instructions to submit to the directors the names of four members, not officers or directors, to serve on the nominating committee for 1920. Seconded by Mr. Johnston. Carried.

Whereupon at 5:45 o'clock p. m., an adjournment was taken until 6:30 o'clock p. m., at which time the meeting was resumed.

Moved by Mr. Bull that the sum of $1000 be set aside and paid over to the technical department out of the earnings of the 1919 Exhibit. Seconded by Mr. Hoyt. Carried.

Moved by Mr. Backert that we appropriate $250 from the earnings of the 1919 exhibition to be paid to the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. Seconded by Secretary Hoyt. Carried.

Secretary Hoyt offered a resolution authorizing the president and secretary-treasurer to open an account in the Harris Trust and Savings Bank of Chicago, make deposits therein and withdraw them by checks duly signed by the president and the secretary-treasurer; and a similar resolution for the establishing of an account in the Standard Trust and Savings Bank of Chicago, for the funds of the department of exhibits.

On motion of Mr. Backert, seconded by Vice President Bean, the resolutions as read by Secretary Hoyt were adopted.

Moved by Mr. Minich that the $5000 set aside as a reserve at last year's meeting be invested in Liberty Bonds. Seconded by Vice President Bean. Carried.

Moved by Mr. Minich that the treasurer be authorized to invest an additional $5000 in Liberty Bonds out of the earnings of the 1919 exhibition, with the understanding that if funds are needed before we have sufficient income from other sources, these bonds be used as collateral for a loan. Seconded by Mr. Hoyt. Carried.

Moved by Secretary Hoyt that the promotion and membership committee be authorized to offer as an inducement to membership

after July 1, membership in good standing to Dec. 31, 1920, including preprints and convention privileges, to all persons who pay the initiation fee and $6.00 dues. Seconded by Mr. Bull. Carried.

Moved by Secretary Hoyt that all who join during convention week and up until the end of the fiscal year, Dec. 31, 1920, and pay the entrance fee of $10.00 and annual dues of $12.00, be made members in good standing until Dec. 31, 1921. The motion was seconded by Vice President Bean. Carried.

Moved by Mr. Bull that all associate members in good standing of this date be accorded full privileges of active membership without payment of any additional fees or dues up to June 30, 1920, and that all associate members who elect on or before July 1, 1920, to accept active membership shall receive a copy of Bound Volume No. 28. Seconded by Mr. Backert. Carried.

Moved by Mr. Bull that the secretary be authorized to have printed 1500 copies Bound Volume of Transactions No. 28. Seconded by Vice President Bean. Carried.

The question of creating a brass or nonferrous section was taken up and discussed at some length. Following discussion it was moved by Mr. Backert that the secretary be instructed to write to Mr. W. M. Corse, chairman of the Metals Division of the American Institute of Mining and Metallurgical Engineers, advising that owing to the large number of requests which we have received from our own members for papers on practical brass founding or nonferrous subjects, it has been decided to devote one or two sessions at our next annual meeting to the discussion of these problems, and realizing that the papers and discussions at the Metals Division have become very technical, it is our thought that they would probably welcome a move of this kind; further, that we would not want this to be construed as in any way interfering with their meeting with us, and that we extend to them an invitation to meet with us in Columbus in 1920. Seconded by Vice President Bean. Carried.

President Koch announced that the committee appointed to nominate four members for the 1920 nominating committee submitted the following names:

S. Griswold Flagg, III., Philadelphia; G. P. Aborn, Blake and Knowles Steam Pump Works, Cambridge, Mass.; A. I. Findley, *The Iron Age*, New York; George L. Grimes, Grimes Molding Machine Co., Detroit.

On motion of Mr. Backert, seconded by Mr. Bean, the report of the committee was adopted, and the foregoing nominated members were declared elected members of the committee.

Vice President Bean moved that the services of E. L. Shaner be secured as secretary to the papers committee at a salary of $100 a month, with an allowance for necessary stenographic assistance. Seconded by Mr. Bull. Carried.

President Koch read a communication from the Association of German Blast Furnace Operators, relative to an exchange of "Stahl und Eisen" and the Transactions of the A. F. A. On motion of Mr. Bull, seconded by Mr. Pero, the communication was placed on file.

Mr. Backert moved that the A. F. A. have absolutely no exchange list. Discussion followed. No action taken.

President Koch submitted correspondence from Mr. Noonan, chairman of the committee on safety and sanitation, relative to the meeting

he attended in Washington on December 9th, of the National Safety Code committee. No action was taken on the communications and reports submitted, but it was understood that President Koch would continue to handle the matter, and if found advisable co-operate with the National Founders' association and present our joint foundry safety code, adopted in October, 1917, and recommend its adoption by the Standard Safety Code committee, appointed by the American Engineering Standards committee.

Communications with reference to the committee on pattern standards, colors, prints, etc., were then presented by President Koch, who advised the progress made in organizing this committee. No action taken.

President Koch announced that in appointing standing committees he thought it would be well to inaugurate a plan of rotation that would result in some new blood on each committee each year, and asked the assistance of the directors in selecting committee members.

It was moved by Mr. Bull that the secretary be instructed to send a telegram to "Daddy Seaman" extending greetings from all the directors present. The motion was unanimously carried.

It was moved by Mr. Bull that a similar message be sent to Mr. Alfred E. Howell and to Past President B. D. Fuller. The motion prevailed.

Mr. Backert moved that the customary $15.00 per diem, railroad fares, and necessary traveling expenses, be paid to directors in attendance at all board meetings, except meetings held during annual convention week. Seconded by Mr. Hoyt. Carried.

Mr. Hoyt moved that the same per diem and traveling expenses be paid to members of the committee on exhibits while transacting exhibition business. Seconded by Mr. Backert. Carried.

Mr. Pero moved that all members of standing and special committees be paid railroad fare and necessary traveling expenses in attendance at meetings of the respective committees. Seconded by Mr. Bull. Carried.

Mr. Hoyt moved that 50 per cent of the expenses of all meetings of the board of directors and committees thereof, with the exception of the exhibits committee, be paid by the technical department, and 50 per cent by the exhibits department, and further, that the expenses of all meetings of the exhibits committee be paid entirely by the department of exhibits, and that all expenses of the papers committee, and other standing committees of the technical department, be paid entirely out of the funds of the technical department. Seconded by Mr. Backert. Carried.

Mr. Bean moved that Secretary Hoyt's suggestion that an auditing committee be added to the list of standing committees be adopted. Seconded by Mr. Messinger. Carried.

The meeting adjourned at 12:00 o'clock.

Approved Dec. 7, 1920.

C. S. Koch, President.
C. E. Hoyt, Secretary.

Annual Report of Manager of Exhibits.

To the Board of Directors, American Foundrymen's Association, Inc.:

I am pleased to submit the following as a report of the 1919 exhibit, held in Exhibition Hall, Philadelphia Commercial Museum, Sept. 29 to Oct. 3, 1919.

This was the fourth exhibit held under the auspices of the American Foundrymen's Association, and the fourteenth to be held in conjunction with the annual meeting of the association. It exceeded both in number of exhibitors and amount of space used, all previous exhibits.

214 firms paid the exhibitor's permit fee and 207 made exhibits, as against 198 who paid the exhibitor's permit fee in 1918, and 194 who made exhibits, which was the record previous to 1919.

The total amount of space used was 60,440 square feet. The largest previous exhibit in amount of space was in Chicago in 1913, when approximately 57,000 square feet were used.

Although every available square foot was used it was not possible to take care of all those who desired space and many of the firms who did exhibit could and would have used considerable more space if it had been available. It is not at all improbable that the total would have reached 75,000 square feet had we been able to provide it.

No increase in space rates were made in 1919, and the average income per square foot was 58.8 cents approximately the same as in 1918 where the average income was 58¼ cents per square foot.

The operating expenses were, however, greatly increased due to the advance in cost of material, labor and all other items. A very considerable increased cost was also due to the character of the building, and the fact that it was necessary for us to provide practically everything with the exception of the four walls and the roof. The average cost of space was 64.6c per square foot.

The building was in a sorry condition when it was turned over to us, and it cost several hundred dollars to remove the debris, clean the floors, whitewash the walls, and wash the windows. We also had to provide our own janitor organization, and the necessary tools. There was not a foot of storage space available in the building, and all crates and boxes had to be hauled away by truck, stored, and then returned by truck when the exhibit was over.

The heaviest item of expense, however, was that of power. This was due to two causes. First, the fact that our power requirements were more than two and a half times greater than they were the previous year. (We had a connected load this year of over 800 horsepower and last year only 300 horsepower.)

But the second and largest item of power expense was due to the fact that it was impossible for the Philadelphia Electric Co. to supply at this building a sufficient amount of power to meet our needs, and provision had to be made to generate this in the building.

As power is one of the principal items of expense, it would be well for us to consider to what extent our exhibitors use power. Of the 207 firms who made exhibits, 105 used some kind of power.

These power users paid $23,394.00 for space, against $12,080.00 paid by exhibitors who did not use power.

The following is a copy of the auditor's statement of receipts and disbursements:

RECEIPTS

Space Rental	$35,474.00		
Exhibition permits	5,350.00		
Gate receipts	2,277.08		
Convention Board, Chamber of Commerce. of Philadelphia	1,500.00	$44,601.08	
Bank Interest		247.31	$44,848.39

DISBURSEMENTS

Administration (Manager's salary)	$6,333.34	
Advertising	3,686.24	
Badges	522.63	
Booth work	3,537.39	
*Building rental	4,145.00	
Cleaning and repairing	692.48	
Committee traveling expense	1,287.08	
Exchange	15.22	
General decorations	1,146.00	
General expenses	204.34	
Installation supt. and asst.	1,240.00	
Installation labor and material	762.69	
Insurance	426.50	
Janitor service	783.00	
Manager's and assts. traveling expense	2,050.57	
Office expense	734.29	
Postage	542.79	
*Power	4,364.53	
Printing and stationery	1,432.06	
Registration expense	433.95	
Secretary's asst. Cleveland office	50.00	
Signs	732.50	
Stenographer and assts.	2,616.79	
Telephone and telegraph	448.38	
Watchmen and doormen	548.00	38,735.77
Excess of Receipts over Disbursements		6,112,62

The audit which was of date Dec. 15 shows the following assets:

Cash in bank	16,814.27
Accounts receivable	506.01
Furniture and equipment	304.50
Surplus—Department of Exhibits	17,624.78

*The lease with the Commercial Museum did not call for payment of cash rental, but it stipulated that all electrical installation work should remain as permanent fixtures. We have charged this item, amounting to $4,145.00 to rent, but for comparison it should be added to the power, which would make this item total $8,509.53.

Of the accounts receivable amounting to $506.01, $412.39 has been collected since the books were closed, making the total accounts receivable on Jan. 10, $83.62. There were no bills payable when the books were audited.

This statement of account does not include booth material that the association owns and which it is difficult to place a value on.

With a loss on space amounting to 5.8c a square foot when space is figured, as is customary, against the entire cost of the year's operation will show that it is necessary for us to make up this loss and a surplus from other sources of revenue, which are exhibitor's permit fees, gate receipts, bank interest and contributions.

The surplus earned in 1916 was $6,829.60, in 1917, $6,701.37; and in 1918, $8,376.12, and with a surplus of $6,112.62 for this year makes the average for the past four years, $7,004.92. This average is helped out considerably by the excess earnings in 1918, which resulted from a 10 per cent increase in space together with the fact that a major portion of the manager's salary and office expenses for the first six months of the year were paid out of the war service committee's fund making a short year for the department of exhibits.

From the above statements it will be seen that the normal average earnings in the past have not been much over $6,000.00 per annum In our opinion this is too small a margin for an undertaking involving an annual expense of nearly $40,000.00, and with the increased cost of all items that enter into the staging of these annual exhibits, the surplus will be much smaller unless the income is increased.

I would recommend for your consideration an increase in the cost of space. It is an interesting coincidence that a 10 per cent increase over the average price for last year would make the income the exact equivalent of the cost of space last year, 64.6c per square foot.

In our report of a year ago we pointed out some of the hazards that confronted us due to the fact that we move from city to city under varying conditions, that our entire income for the year is dependent on one week's operation, and recommended that a reserve fund be set up. The board voted to set aside $5000.00 out of the earnings of the 1918 exhibit.

There are large responsibilities in an undertaking of the character and magnitude that these exhibits have assumed, which can not entirely be insured against, and I believe that it should continue to be our policy to build up a reserve fund until we have an amount comparable with the expenses of one year's operation.

We have prepared a financial statement supplementing the auditor's report showing disbursements under each ledger account. Also a complete schedule showing amounts received from each exhibitor on account of permits, space, power, labor and material, and these are submitted with the auditor's report for your examination and consideration.

Respectfully submitted,

C. E. HOYT, *Manager of Exhibits.*

MINUTES OF THE MEETING OF THE 1920 EXHIBIT COMMITTEE, HOTEL DESHLER, COLUMBUS, WEDNESDAY, APRIL 28, 1920.

Present: President C. S. Koch, Vice President W. R. Bean, H. R. Atwater, S. T. Johnston, J. P. Pero, J. C. Pangborn, and C. E. Hoyt, secretary.

A meeting of the committee on promotion and membership had also been called for the same day, and Alfred E. Howell, chairman, A. O. Backert, secretary, and W. A. Janssen of this committee were present and sat in at the meeting of the convention and exhibit committee, as did also Colonel T. S. Hammond, chairman of the entertainment committee, D. M. Avey and W. B. Robinson, members of the committee.

Preceding a formal meeting of the committee, the entire delegation was escorted by local representatives, to the Ohio State Fair Grounds, where they inspected the buildings that will be used for the 1920 convention and exhibit. On returning to the Hotel Deshler the meeting of the committee was called to order by President Koch.

The first order of business was the reading of memorandum of agreement between Secretary N. E. Shaw, representing the State Board of Agriculture and Secretary C. E. Hoyt, representing the American Foundrymen's Association, the agreement being in the nature of a lease for the use of the State Fair Grounds.

The secretary next read a draft of rules and regulations for the exhibit, all of which were favorably passed upon by the committee and ordered to be made a part of each contract for space.

Following discussion on general decorations for buildings, it was moved by Mr. Minich and seconded by Mr. Atwater, that the secretary be authorized to spend not to exceed an average of $500.00 per building, for general overhead decorations. Motion carried.

The secretary pointed out that with the growth of the exhibit, it would be necessary to place some limitation on the amount of power that could be furnished, particularly in supplying compressed air, and following discussion it was moved by Mr. Minich and seconded by Mr. Atwater that each exhibitor be limited to 200 cubic feet of free air per minute providing the requirements of others made necessary such limitations. Motion carried.

A publicity campaign was discussed and it was the consensus of opinion that the best results could be obtained by a personalized campaign, and it was moved by Mr. Pero and seconded by Mr. Bean, that the association avail itself of the personal mailing list of the Foundry Equipment Association, providing it was found possible to make such an arrangement. Motion carried.

Moved by Mr. Minich and seconded by Mr. Pero, that a sum not to exceed $5000 be appropriated to defray the cost of the proposed publicity campaign.

The secretary pointed out that due to conditions at the Fair Grounds, with seven or eight separate buildings being used, it would be necessary to charge an admission at the gate. It was duly moved and seconded that this be done and that tickets of ad-

mission be mailed to all members of the association prior to the convention, which would be exchanged at the registration desk for a season pass. Motion prevailed.

The question of providing multigraph copies of registration at frequent intervals throughout the day was discussed, and after due consideration it was moved by Mr. Johnston and seconded by Mr. Atwater, that the practice of making multigraph copies be discontinued. Motion carried.

It was moved by Mr. Pangborn and seconded by Mr. Pero, that as a substitute for the multigraph copies, a daily list of attendance be printed, arranged alphabetically by firm with hotel addresses. Motion carried.

President Koch at this point, requested Mr. Howell, chairman of the promotion and membership committee to take the chair, while questions pertaining to the work of this committee be discussed.

Mr. Howell read a letter from Mr. Messinger who was unable to be present, offering many good suggestions for a membership campaign.

Mr. Backert, secretary of the committee, outlined a plan for a membership drive which would culminate in a "Foundrymen's Week," with the necessary machinery to make possible every foundryman in the United States and Canada not affiliated with the Association, receiving a personal invitation to membership from some member in his district.

This plan was favored by all present and it was moved by Mr. Johnston and seconded by Mr. Atwater that the secretary be authorized to employ, under the direction of the committee on promotion and membership, such clerical and technical assistance as was necessary to carry on the membership campaign as outlined. Motion carried.

President Koch, again in the chair, called for a report from Mr. Hammond, chairman of the entertainment committee, who had been in separate session in an adjoining room.

Mr. Hammond submitted a tentative program, embracing entertainment features for visiting ladies, field sports, a smoker, and estimating contests. Chairman Hammond estimated that to carry out the proposed program they would need approximately $3500.

It was moved by Mr. Johnston and seconded by Mr. Minich that the report of the entertainment committee be accepted and that they be voted funds from the department of exhibits, an amount not exceeding $3500, for defraying the expenses of the entertainment program.

The committee meeting adjourned at 6 p. m., Columbus time.

C. S. Koch, President.
C. E. Hoyt, Secretary.

Minutes of Meeting of the Board of Directors Held at Columbus Athletic Club, Columbus, Tuesday Oct. 5, 1920

The annual dinner of the board of directors and honorary members of the American Foundrymen's Association was held at the Columbus Athletic club, Columbus, Tuesday evening, Oct. 5, 1920.

The regular call for a meeting of the board of directors had been made, and as is customary, all members of the advisory board had been invited to attend. Following the dinner the meeting of the board convened with President Koch in the chair.

The following directors were present:

C. S. Koch, president, and W. R. Bean, vice president. H. R. Atwater, A. O. Backert, H. A. Carpenter, S. B. Chadsey, Alfred E. Howell, W. A. Jänssen, C. R. Messinger, V. E. Minich, J. P. Pero, A. B. Root Jr., Roy Tanner, R. A. Bull, S. T. Johnston, and C. E. Hoyt, secretary.

The following members of the advisory board were also present:

Chris. J. Wolff, president, 1905; W. H. McFadden, president, 1907; B. D. Fuller, president, 1918; John A. Penton, secretary, 1896 to 1899; Richard Moldenke, secretary, 1900 to 1914; and as a special guest of the evening, C. B. Connelley, commissioner of labor, State of Pennsylvania.

Following introductory remarks by President Koch, the meeting was addressed briefly by Mr. Connelley and Mr. Wolff.

President Koch then announced that Major R. A. Bull had a message from Mr. J. S. Seaman, president of the association in 1900, who had hoped to be with us, but was unable to attend. Mr. Bull stated that Mr. Seaman had long desired to do something to encourage young men in the foundry industry and stimulate them in research in foundry problems.

Major Bull stated that to this end Mr. Seaman had placed in his hands $5,000.00 in United States Liberty Bonds, as a gift to the American Foundrymen's Association, the interest therefrom to be used by the board of directors in making awards of a suitable nature, to be given for meritorious effort in the foundry industry. This might be for a paper presented, for some development of a process, or invention of a mechanical device. The details of making these awards Mr. Seaman desired to leave entirely in the hands of the board of directors.

Major Bull stated further, that Mr. Seaman had no desire whatever, that his name be used in connection with these awards, and would be content with any decision reached by the board, but that he desired a condition observed that shall cause the transmission to his heirs of the amount of the principal should the association be disbanded.

In conclusion Mr. Bull stated that he felt highly honored in having been delegated as spokesman for Mr. Seaman on this occasion, and then placed in the hands of President Koch, United States Liberty Bonds of a par value of $5000.

Mr. Howell promptly moved a vote of thanks to Mr. Seaman and that a telegram be forwarded expressing appreciation on behalf of the members and officers of the association.

The motion was seconded by Mr. Pero and was unanimously and enthusiastically adopted by a rising vote.

"Dear Daddy:

Your gift presented first to the alumni dinner and tonight to the convention. Greatest enthusiasm manifest. Letter to follow conveying action of the association. With grateful feelings and love to you this message is sent by direction of the board.

C. S. Koch, President.
C. E. Hoyt, Secretary.

President Koch then called attention to remarks by Mr. John A Penton at the annual dinner and meeting of the board in Philadelphia. September, 1919, in which he pointed out the advantages that would accrue to the association and to the foundry industry if an award or awards were offered annually to those who excel in achievement in the foundry field, and said that he personally would take great pleasure in offering such an award.

Mr. Koch stated further, that it was moved that a vote of thanks be extended to Mr. Penton and that a committee be appointed to confer with him as to the details of handling the contribution or endowment which he proposed to make.

Mr. Koch said that the committee which he had appointed had not made a final report, but that all present would be pleased to hear from Mr. Penton as the one who first suggested the idea of an endowment for awards by the association.

Mr. Penton responded by again expressing his great interest and desire to stimulate advancement in the foundry industry, and, said to this end he was ready to contribute the sum of $5000, the proceeds of which he suggested be used to purchase an award for that person who made the most noteworthy contribution along the line of electric furnace practice in the melting and refining of ferrous and nonferrous metals, the details of making the award to be left to the board of directors.

Mr. Howell promptly moved a rising vote of thanks to Mr. Penton, which was seconded by Mr. Carpenter and unanimously and enthusiastically adopted.

Mr. Penton again addressing the chair, stated that he was authorized to say for Mr. J. H. Whiting, of the Whiting Foundry Equipment Co., that he would be pleased to contribute to the American Foundrymen's Association, the sum of $5000, the proceeds of which Mr. Whiting had suggested be used to purchase an award for that person who made the most noteworthy contribution each year, in the melting of metals in the cupola or air furnace.

Mr. Howell moved a rising vote of thanks to Mr. Whiting. The motion was seconded by Mr. Bean and unanimously given.

Mr. Howell moved that the president appoint a committee to whom the various offers for establishing endowments be referred, this committee to confer with the donors and report back to the board of directors with recommendations for a definite plan of procedure. Motion seconded by Mr. Bean and unanimously carried.

Mr. W. H. McFadden asked permission to address the meeting, and after some apt preliminary remarks indicating his lasting interest in the

foundry industry and in the association, of which he was president in 1907, stated that he too would gladly contribute the sum of $5000, the proceeds of which could be used in a similar manner to contributions that had been made before, and that as soon as the board or the special committee appointed for the purpose had determined upon a definite plan and had drawn the proper papers, he would be glad to forward his check.

Major Bull promptly moved a rising vote of thanks to Mr. McFadden to which there were several seconds and it was adopted with a hurrah.

After informal discussion it was proposed that announcement of these contributions be deferred until the annual banquet on the following evening.

The secretary made a brief report, citing membership increase under the splendid work of the committee on promotion and membership, of which Mr. Howell was chairman.

Speaking of the exhibits, the secretary stated that the total amount of space used was 25 per cent larger than any previous year and added that while the bank balance in both departments was in a healthy condition, there would still be large bills to pay on account of the convention and exhibit, but that he hoped we would end the year with the balance on the right side of the ledger.

Discussion followed on the subject of accommodations for our largely increasing convention and exhibit and it was suggested that this was a question which might be deferred to the executive committee for their deliberation and to report at some future meeting.

The secretary read a letter from the American Sand Association on the subject of car shortage for the transportation of foundry sands, following which it was moved that the secretary be instructed to draft resolutions along the lines outlined in the letter just read, and forward same to the proper authorities in the name of the association.

Mr. Backert, commenting on the extent and success of the convention and exhibit, proposed a rising vote of appreciation for the secretary and manager of exhibits, which was responded to in a way that was very gratifying to the secretary, who expressed his very deep appreciation of the support and co-operation accorded him by all of the officers, directors and members, and for the vote of appreciation and confidence given.

The 100 per cent attendance of officers and directors, together with others present, were unanimous in feeling that the splendid contributions which had been offered were fittingly appropriate, coming as they did on the occasion of the twenty-fifth anniversary of the association the first convention being held in Philadelphia in 1896. The meeting adjourned at 11:00 p. m.

C. S. Koch, President.
C. E. Hoyt, Secretary.

Minutes of Annual Meeting of the Board of Directors of the American Foundrymen's Association, Genesee Valley Club, Rochester, N. Y., Tuesday, Dec. 7, 1920, 10 A. M.

This meeting, called by the retiring president, Mr. C. S. Koch, in accordance with the provisions of the by-laws, was for the purpose of receiving reports and completing the work of the past year.

Officers and directors present were:

C. S. Koch, W. R. Bean, C. E. Hoyt, H. R. Atwater, A. O. Backert, R. A. Bull, H. A. Carpenter, A. E. Howell, W. A. Janssen, S. T. Johnston, C. R. Messinger, V. E. Minich, J. P. Pero and A. B. Root Jr. There were also present by invitation, G. H. Clamer, L. W. Mueller, Fred Erb and B. D. Fuller, directors elect for the year 1921.

Absent:

S. B. Chadsey and J. Roy Tanner.

President Koch in the chair stated that the first order of business would be the reading of the minutes of the meeting of the board of directors at Cleveland, Jan. 13, 1920, as these minutes had not been read or approved at any previous meeting.

Secretary Hoyt read the minutes which, on motion duly seconded, were approved as read.

The secretary read the minutes of the directors meeting at the Athletic Club in Columbus, Tuesday evening, Oct. 5, 1920, which was preceded by the annual dinner of officers and directors.

On motion, duly seconded, the minutes were approved as read.

The secretary read his annual report, which was in the nature of a report for the executive committee.

On motion duly seconded, the report was received and ordered filed.

Mr. Hoyt read his report as manager of the 1920 exhibit.

At the request of Mr. Bull the report was changed in such a manner as to show more clearly the source of receipts resulting in a net profit for the year's operation.

Mr. Hoyt then submitted a financial statement, reading first the report of Ernst & Ernst, auditors, who had audited the books of the department of exhibits as of date of Nov. 30, 1920. This audit showed an operating profit of $9,644.62.

Mr. Hoyt explained that from this should be deducted three items of expense, bills for which had not been rendered prior to the books being audited. These items included water and electricity at the State Fair Grounds, and insurance on the buildings occupied, and all told totaled $1,386.17, which would leave the operating profit $8,258.45 less any minor outstanding obligations for which bills had not been presented.

Mr. Hoyt explained in detail the expenditures under each ledger heading.

On motion duly seconded, the report of the manager of exhibits was received and ordered filed.

The question of setting aside a portion of the earnings to be added to the reserve fund, and voting the usual sums to the tech-

nical department, and the Institute of Metals Division of the A. I. M. E. was discussed.

Following the discussion it was duly moved and seconded that a committee of three be appointed by the president to take under consideration the whole subject of appropriations, and report after luncheon.

The chair named as this committee, A. O. Backert, G. H. Clamer and S. T. Johnston.

B. D. Fuller, chairman of the committee on safety, sanitation and fire prevention, reported that on July 7 the joint committee of the National Founders' Association and the American Foundrymen's Association, submitted to the Engineering Standards Committee the joint foundry safety code of these Associations as the code recommended by the sponsors committee of their appointment.

Mr. Fuller stated further, that the Engineering Standards Committee after considering the report, recommended that the committee be enlarged by the addition of other organizations, and suggested the American Society of Mechanical Engineers, International Association of Industrial Accident Boards and Commissions, National Association of Manufacturers, National Council of Workmen's Compensation Service Bureau and the National Safety Council.

Mr. Fuller reported, that at a conference with Mr. Boggis, recommendations provided the consent of the respective organizations could be obtained.

On motion, duly made and seconded, the recommendations were authorized by the board of directors, and Mr. Fuller given full authority to represent the association in presenting the joint safety code for adoption.

The meeting then adjourned for luncheon.

Following luncheon the board was escorted by a local committee to the Rochester Exposition Park where they inspected the buildings offered by the city of Rochester for the 1921 convention and exhibit.

On returning to the Genesee Valley Club the meeting was again called to order with President Koch in the chair.

The report of the special committee appointed to consider appropriations was called for.

Mr. Backert for the committee, recommended that the sum of $5000 be set aside out of the earnings of the 1920 exhibit and added to the reserve fund.

That $250.00 be voted to the Instituteof Metals Division of the A. I. M. E.

Mr. Backert stated that the committee in determining the amount to be transferred to the technical department, considered the suggestions that had been offered for the publication of a bulletin or some official organ of the association, and rendering a larger service to the members during the interim between conventions, and with this in mind, recommended that the sum of $3000.00 be appropriated for work of the technical department, $1000.00 to be transferred immediately and the balance as needed.

The committee further recommended that a publicity committee be appointed for the purpose of putting the recommendation of the committee for an official organ into effect.

On motion, duly seconded and carried, the report of the committee was accepted and the disposition of funds of the department of exhibits voted as recommended, and the officers given authority to em-

ploy the assistance necessary to carry on the proposed increased activities.

Mr. Hoyt reporting on the contributions announced at the Columbus, convention, stated that he had on deposit with the Harris Trust Co., Chicago, $5000.00 in U. S. Government Bonds, received from Mr. J. S. Seaman, of Pittsburgh, and $1000.00 in U. S. Government Bonds, received from S. Obermayer Company, Chicago, and further, that Mr. John A. Penton, of Cleveland, Mr. W. H. McFadden, of Ponca City, Oklahoma, and Mr. J. H. Whiting, of Chicago, were prepared to make their contributions of $5000 each, as soon as the details of the handling of the funds had been determined.

Mr. Hoyt stated that the above contributions, totaling $21,000.00 were endowments, the income from each to be used for stimulating effort in the foundry industry by making it possible for the association to offer medals and premiums for meritorious work.

Mr. Hoyt reported further that he had on deposit in a special savings fund, with the Harris Trust Company, Chicago, $2500.00 received from Mr. Thomas W. Pangborn and Mr. John C. Pangborn, of Hagerstown, Md., which contribution was made at the Columbus Convention as an outright gift to the association, the principal or interest to be used for research work or any special work at the discretion of the board of directors.

It was duly moved and seconded that the officers of the association be instructed to draft formal resolutions accepting each of the gifts that had been announced by the secretary. Motion unanimously carried.

Mr. A. B. Root Jr., offered the following resolution:

Resolved: That the officers of the association be instructed to draw up, under legal advice, proper forms of agreement for formal acceptance by the board of directors of the American Foundrymen's Association, of the various funds which have been entrusted to their keeping, the interest or principal of which, as expressed in the gift, to be used as awards for meritorious services, on subjects selected by the board, taking into consideration the preference of subjects as expressed by the donor.

This resolution was seconded by Mr. V. E. Minich and carried.

Mr. C. B. Connelley, chairman of the committee on awards, had been invited to be present and report for his committee. Mr. Connelley stated that a meeting was held in New York, Nov. 9, at which time the committee considered the various conditions and fields of endeavor under which each award placed at the disposal of the association might be contested for. A draft of the findings of the committee was submitted and read.

General discussion followed, after which it was moved by Mr. Minich that the report of the committee be accepted and referred to the awards committee to be appointed by the incoming administration. Motion duly seconded and carried.

Mr. Bean reported a conference which he had had with Professor C. A. Adams, chairman of the engineering division of the National Research Council, at which Mr. Backert, Mr. Johnston, Mr. Bradley Stoughton and Mr. Hoyt were present, at which time the question of using the funds contributed by Messrs. Thomas and John Pangborn for conducting a research for the reclamation of used foundry sands was considered.

Professor Adams stated that the National Research Council would be agreeable to co-operating with the A. F. A. in this work and

agreed to submit in writing, suggestions as to how the work might be organized and financed.

Mr. Bean then read a letter received from Professor Adams under date of Nov. 26, outlining a plan for organizing committees for this work.

Following Mr. Bean's report there was a general discussion on the question of securing funds for research work, and it was suggested that some of the funds that had been placed at the disposal of the association might be combined as a nucleus for a larger fund to be raised for this purpose.

Mr. Messinger moved that the matter reported by Mr. Bean be referred to the incoming board and its committees for consideration, and further, that it was the sense of this board that each contribution or award that had been received should be kept as a separate fund. Motion seconded by Mr. Minich and carried.

President Koch then read a letter from the Debevoise-Anderson Co., of New York, advising that they had under consideration the setting aside of $1000.00 to be placed at the disposal of the American Foundrymen's Association, the income to be used in making an annual award for meritorious achievement in the foundry industry.

On motion duly seconded, the secretary was instructed to correspond with the Debevoise-Anderson Co., thanking them for their offer, and advising the general conditions under which the association would be pleased to accept contributions.

Mr. Howell, reporting for the committee on promotion and membership of which he was chairman, made a statement of results of the membership campaigns in 1919 and 1920. From July 1 to Dec. 3, 1919, 210 members were elected. From July 1 to Dec. 1, 1920, 442 members were elected, making a total of 652 for the two campaigns conducted over a period of seventeen months.

Mr. Howell stated that preliminary to the membership campaign in 1920, the committee had promised some special recognition for all team captains or members securing five or more new members.

It was moved by Mr. Bull that the report of Mr. Howell for his committee be accepted with the thanks of the board for the splendid results accomplished, and that the chairman of the committee be authorized to provide, at the expense of the association, some memento or souvenir for those members who had secured five or more members, and further, that the secretary be instructed to secure for Mr. Howell, some special memento in recognition of his splendid work as chairman of the committee. Motion seconded by Mr. Pero and carried.

At the request of Mr. Messinger, Mr. Hoyt retired from the room and the board went into executive session, when Mr. Messinger offered the following motion:

RESOLVED: That C. E. Hoyt, Manager of Exhibits, be paid a bonus of $1500.00 out of the earnings of the 1920 exhibit in recognition of his faithful endeavor throughout the year, and successful handling of the Columbus convention and exhibit under unusually trying conditions in transportation, labor, etc. The motion was duly seconded and unanimously carried.

Mr. Hoyt on being advised of the action of the board, expressed his very great appreciation and stated that it would be his pleasure to share his bonus with the members of his official staff.

Mr. Bull, stating that it would be in order for this board to confirm the election of C. S. Koch to honorary membership by the members at the annual meeting of the Association in Columbus, Oct. 8th, moved that this be made a matter of record. Motion was seconded by Mr. Howell and unanimously carried.

Mr. Bull moved that all acts of the executive committee and officers during the past year be, and hereby are, approved and ratified by the board. Motion duly seconded and carried.

The secretary reported that the result of the mail ballot by the members for officers and directors of the association as announced by the tellers at the annual meeting in Columbus, October 8, 1920, was as follows:

For President:

W. R. Bean, Eastern Malleable Iron Co., Naugatuck, Conn.

For Vice President:

C. R. Messinger, Sivyer Steel Casting Co., Milwaukee, Wis.

For Directors for three years:

A. O. Backert, Penton Publishing Co., Cleveland.
R. A. Bull, Sewickley, Pa.
W. A. Janssen, American Steel Foundries Co., Chicago.
C. S. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.
V. E. Minich, American Foundry Equipment Co., New York.

For Directors for two years:

H. R. Atwater, Osborn Mfg. Co., Cleveland.
S. B. Chadsey, Massey-Harris Co., Ltd., Brantford, Ont., Can.
Alfred E. Howell, Nashville, Tennessee.
S. T. Johnston, S. Obermayer Company, Chicago.
J. P. Pero, Canadian Car & Foundry Co., Ltd., Montreal, Que., Can.

For Directors for one year:

G. H. Clamer, Ajax Metal Co., Philadelphia.
Fred Erb, Packard Motor Car Co., Detroit.
B. D. Fuller, Defiance Paper Co., Niagara Falls, N. Y.
C. E. Hoyt, Chicago.
Lucien W. Mueller, H. Mueller Mfg. Co., Decatur, Ill.

President Koch announced that in accordance with the by-laws the newly elected officers and directors would assume office immediately upon adjournment of this board, and that if there was no further business, he would declare the meeting adjourned and turn the gavel over to President-elect Bean.

Whereupon, there being no further business, the final meeting of this board stood adjourned.

C. S. Koch, President.
C. E. Hoyt, Secretary.

Annual Report of Manager of Exhibits

To the Board of Directors, American Foundrymen's Association, Inc.:

I am pleased to submit the following as a report of the 1920 exhibit, held on the State Fair Grounds, Columbus, O., Oct. 4 to 8, 1920.

This was the fifth exhibit held under the auspices of the American Foundrymen's Association, and the fifteenth exhibit of foundry machines and equipment held in conjunction with the annual conventions of the association.

There was a total of 241 exhibits as against 207 exhibits in 1919, which was the record up to that date, a net gain in number of exhibits of 34.

The total exhibit space used, exclusive of aisles was 76,600 square feet. The largest previous exhibit, which was in 1919, was 60,440 square feet, showing a net gain of 16,160 square feet. This exhibit was installed in seven different buildings, and it is interesting to note that every booth shown on the floor plans prepared for each building was occupied, and so far as is known every manufacturer desiring space was able to secure it.

In preparing a financial statement it has been customary in years past to figure against space sold the total expenses of the department of exhibits for the entire year, and with but a single exception in the past, space alone has failed to earn a profit. In 1918 the average price of space per square foot was 58.3 cents; in 1919 the price was 58.8 cents.

In our report of a year ago we showed that the total expenses of the year figured 64.6 cents per square foot of space used, showing a loss of 5.8 cents on each foot, approximately 10 per cent, and it was recommended that an increase of 10 per cent be made in space for 1920.

This increase made the average price of space for this year 64.9 cents, and it is interesting to note that the total expenses of the year figured against the total space amount to 64.8 cents, showing a net profit on space of $53.23. The balance of the net earnings shown in the auditors' report was made up from exhibitors' permit fees, gate receipts, and bank interest.

I will now read the report of the auditors, Ernst & Ernst, who audited the books for the department of exhibits on Nov. 30, 1920, the previous audit being on Dec. 5, 1919.

(Manager reads report.)

You will note that the auditor's report shows excess of receipts over disbursements to be $9,644.62, but from this amount should be deducted four items of expense bills for which had not been rendered at the time the books were audited. These items include bills for water and electricity at the State Fair Grounds, insurance for one month on all the buildings occupied, and miscellaneous power and advertising, totaling $1,386.17, which would leave the net operating profit $8,258.45.

In our report of last year we gave the average earnings for the department of exhibits for four years as $7,004.91. It will be seen therefore that we have siightly increased the average although general expenses were heavy.

As usual the largest individual item of expense is that of power. Some day we hope to be so fortunate as to exhibit in a building where there is ample power for our requirements. It was necessary to bring primary wires to the building from a distance of nearly a mile, and then because of our using power in several different buildings, it was necessary to install four transformer stations, one of 75 kilowatt, one of 100 kilowatt, one of 150 kilowatt, and another of 225 kilowatt. In each building it was also necessary to install panels, distributing boards, and run the secondary feed lines.

The gross cost of power, both electric and air, including equipment, freight, cartage, and labor, was in excess of $15,000.00. This was reduced by materials returned and by amounts collected from exhibitors, to $8,794.64.

The next largest item of expense was booth construction and decorations, which totaled $6,827.45, an increase of $1,411.56 over 1919, but it is interesting to note that figured on the square foot basis it cost exactly 9 cents per square foot each year.

We have prepared a statement showing all items of disbursement under each ledger account, also a complete schedule showing amounts received from each exhibitor on account of exhibitor's permits, space, power, labor, and material, which we will respectfully submit with the auditor's report for your examination and consideration.

C. E. HOYT, MANAGER.

Auditor's Report for Department of Exhibits

Mr. C. S. Koch, President,
American Foundrymen's Association,
Chicago.

Dear Sir:—

As requested we have made an examination of the books of account and records of the department of exhibits of the American Foundrymen's Association, Chicago, for the period beginning Dec. 15, 1919, and ending Nov. 30, 1920, and submit the following report.

The surplus balance at Nov. 30th, 1920, consists of the following assets:

Cash in bank	$13,185.24
Liberty Bonds—par value $11,500.00	10,099.85
Exhibitors' accounts	2,340.66
Technical dept. Am. F. Ass'n.	1.50
Furniture and equipment	523.50
	$26,150.75

The excess of receipts over expenditures for the period under review is $9,644.62, as shown in a detailed schedule attached. We were informed by the secretary that all liabilities to Nov. 30th, 1920, were included with the exception of the following which are withheld pending adjustment negotiations in progress at this time.

State Fair, Columbus, Ohio —for water	$368.85
Columbus Electric Ry. Power and Light Co.—for light	392.12
	$760.97

We present herewith, a detailed schedule showing the transactions affecting the surplus account during the period.

We verified the cash in the bank by direct correspondence with the depositary.

The department of exhibits purchased during the year, $11,500.00 par value Second Liberty Loan converted 4¼ per cent gold bonds, at a cost of $10,099.85. These bonds were presented for our inspection. The bonds are kept in a safety deposit vault of the Harris Safe Deposit Co., Chicago, Ill., and are accessible to the secretary or his assistant, Mr. C. E. Hoyt and Miss J. Reininga.

The accounts of exhibitors are shown in detail in a separate schedule attached. As requested we did not verify any of these accounts from an independent source.

Data supporting additions to the furniture and equipment account were examined and appeared to be proper charges. As requested we made no provision for depreciation.

The cash receipts as recorded in the cash book during the period under review were reconciled with the deposits as shown by the bank statements on file. All canceled checks returned by the bank for the period were compared with the book entries. Invoices supporting the disbursements were examined. All footings of the cash receipts, cash disbursements and general ledger were verified. General ledger postings were checked and no errors noted.

Yours very truly,

Ernst and Ernst,
Certified Public Accountants.

RECEIPTS AND DISBURSEMENTS

For the period beginning Dec. 15, 1919, and ending Nov. 30, 1920.

RECEIPTS

Exhibitors' permits		$ 6,025.00	
Space rental	$50,130.00		
Less allowance for compressed air furnished	375.00	49,755.00	
Gate admissions	3,315.25		
Less war tax paid	257.14	3,058.11	
Entertainment tickets		409.00	
Power		6,424.67	
Labor		171.20	$65,842.98
Interest on bank balance	263.78		
Interest on Liberty bonds	245.50	509.28	
Office rent		160.00	669.28
			66,512.26

DISBURSEMENTS

Advertising		6,124.37	
Badges		499.34	
Boothwork and decorations		6,827.45	
Committee travel		1,344.80	
Convention souvenirs		1,615.48	
Entertainment		1,930.05	
Exchange		24.50	
General expense		277.04	
Installation labor and material		1,622.41	
Installation supervision		1,300.00	
Insurance		321.63	
Janitor service		830.95	
Manager's salary		7,283.29	
Manager's assistant salary		300.00	
Manager & assistants' traveling		1,701.54	
Office expense		252.94	
Postage		408.55	
Power		15,219.31	
Printing & Stationery		1,805.45	
Registration expense	2,170.66		
Less allowance by Tech. Dept.	300.00	1,870.66	
Office rent	666.00		
Office purchase of lease	850.00	1,516.00	
Stenographic salaries		2,905.95	
Telephone and telegraph		335.93	
Watchmen service		460.00	56,867.64
Excess of Receipts over Disbursements			9,644.62

Manager's Note:

The following items for which bills were not received before books were audited were paid in December and should be deducted from the operating profit for 1920.

Ohio State Fair grounds for Water.	368.85		
Light.	384.86	753.71	
Power		179.66	
Advertising		15.00	
Insurance		437.80	1,386.17
Net Excess of Receipts over Disbursements			$ 8,258.45

Annual Report of the Secretary-Treasurer

To the President and Members of the American Foundrymen's Association, Inc.:

From the date of organization in 1896 to 1911, the annual meetings of the association were held during the months of May or June, and with the fiscal year ending as it did on June 30, the secretary's annual report could contain a full report of the year's activities, including the annual convention just passed.

With the change from the spring to fall meetings, which was made in 1911, the fiscal year closed just prior to the convention and the annual report of the secretary for that year contained a report of the convention held the previous year.

With the year ending as it now does, December 31, and the annual meeting of the board of directors falling on the first Tuesday after the first Monday in December, the secretary's annual reports and the auditor's statements will cover one full year's operation, including the annual meeting and convention of that year.

It was thought that the best way to make the change from a June 30 to Dec. 31 year would be to carry through for 18 months, and the following report is for the period of July 1, 1919 to Dec. 31, 1920. The auditor's report submitted herewith is for the same period.

In our report of June 30, 1919, published in Bound Volume No. 28, we give the book membership as 1103. During the following six months, ending Dec. 31, 1919, 209 new members were elected and 76 names removed from the books, making the membership 1236, a net gain of 133 for the six-month period.

During 1920, 455 new members were elected and 58 removed from the books, leaving our total book membership on Dec. 31, 1920, 1633, a net gain for the year of 397. When the by-laws were revised the 116 associate members on our books

were offered active membership without the payment of entrance fees. Of these 109 elected to accept active membership, 3 resigned, and from 4 no response was received.

Following is a table showing new members elected by months for the past year:

Report on Membership, December 31, 1920

Total membership to January, 1 1920			
	Active	1217	
	Honorary	19	
			1236
New Members during 1920:	January	3	
	February	2	
	March	16	
	April	13	
	May	9	
	June	14	
	July	31	
	August	49	
	September	171	
	October	127	
	November	8	
	December	12	455
			1691
Members resigned during 1920		37	
Dropped for nonpayment		13	
Mail returned		4	
Deceased		4	
Total removed from records during 1920			58
Book membership Dec. 31, 1920			1633

Accompanying this report is a chart showing the membership of the association each year since the date of its organization in 1896.

We also show a map of the United States on which is indicated the total number of members and the total number of foundries in each state of the Union and Canada. The number and distribution of foreign members will be found in the Yearbook.

Finances

As the auditor's report is for a period of 18 months during which time the two largest conventions of the association were held, comparison cannot be made with previous reports covering one year's operation. The expenses of the association have

Chart Showing Growth of Membership of American Foundrymen's Association.

greatly increased during the period under review. This is due, first, to an increased volume of business resulting from increased membership and broader activities, and second, to increase in cost of material and services. Our printing and stationery, for instance, which is the largest item of expense, cost $10,068.45 for the twelve months ending Dec. 31, last, as against $5,349.76 for the twelve months ending June 30, 1919.

Another item of expense which is an indication of the increased volume of business is postage, amounting to $1,803.49 for the past twelve months as against $762.25 for the twelve months ending June 30, 1919. Salaries, which is the second largest item of disbursement in the report, includes the secretary's salary of $200.00 a month and the salary of the secretary to the papers committee and editor of transaction of $100.00 per month. An increased number of committee meetings together with the increased cost of railroad travel has added to the cost of this item of expense. During the period under review $2,000.00 were transferred from the funds of the department of exhibits to the technical department, $1,000.00 being from the earnings of the 1919 exhibit and $1,000.00 from the earnings of the 1920 exhibit. In the auditor's report this sum is credited to convention expenses. At the annual meeting of the board of directors Dec. 7, 1920, the transfer of an additional $2,000.00 was authorized toward defraying the expense of special work under consideration. $250.00 was voted from the funds of the department of exhibits to the Institute of Metals Division of the A. I. M. M. E. following the Philadelphia exhibit and another $250.00 following the Columbus exhibit.

Research Fund

Our research fund of $372.13 shown in our last report has been increased by interest and a contribution of $2500.00 by Mr. Thomas W. Pangborn and Mr. John C. Pangborn, of Hagerstown, Maryland, and at the present time totals $2907.39. The hope expressed in our last report that this fund would soon be added to making possible the association undertaking research work which would be of value to the industry has been handsomely responded to by the Messrs. Pangborn. This is the

Courtesy of "The Foundry"

the figures shown in circles represent total number of A. F. A. members, the figures outside the circles the number of foundries of all classes.

first contribution received from individuals; the original fund, amounting to $337.11, was contributed by the Cleveland local committee following the 1916 convention in that city.

Record Convention

The twenty-fifth anniversary convention furnished the high-water mark in attendance, in the excellence of the technical program, and in the proportions and quality of the exhibits, which occupied 76,000 square feet of space exclusive of aisles. It was the largest exhibit of foundry equipment and supplies ever held in this or any country.

Awards

Probably the most outstanding events of the year, and those which will cause the twenty-fifth annual meeting to be remembered as long as the association continues, were the splendid contributions announced during convention week. Mr. John A. Penton, one of the organizers and secretary of the association from date of organization in 1896 to 1899, Mr. J. S. Seaman, president of the association in 1900, Mr. W. H. McFadden, president of the association in 1907, and Mr. J. H. Whiting, all charter members of the association, offered to contribute the sum of $5,000.00 each, and Mr. S. T. Johnston, another charter member, pledged $1,000.00 for the S. Obermayer Co., making five individual award funds totalling $21,000.00 the income from which is to be used for making annual awards for meritorious work in the foundry field.

Expressions of appreciation for these splendid gifts have been written and spoken, but the closing paragraph of the report of the committee on resolutions read by Chairman Alfred E. Howell at the annual meeting will bear repeating here:

"Mark Antony was made to say 'The evil men do lives after them; the good is oft interred with their bones.' This good these men have done shall live after them, and the results be apparent and lasting and cumulative ages after we, like flocks of morning cloud, shall have faded into the infinite azure of the past."

Institution of British Foundrymen

During the past year closer relations have been established with the Institution of British Foundrymen. In annual convention in August 1920 the members of the Institution of British Foundrymen sent formal greetings and sincere good wishes for the success of our convention. These were presented at the annual meeting and the officers were formally instructed to respond to the greetings and extend a hearty invitation to the members of the Institution of British Foundrymen to meet with us in joint convention in 1921, or some later date.

Exchange of Papers

An exchange of papers between the Institution of British Foundrymen and the American Foundrymen's Association has been arranged for during the past year. In these negotiations we were represented by Mr. H. Cole Estep, who for a number of years was chairman and secretary of the committee on papers and now resides in London. In accordance with the plans outlined one of our members will prepare a paper to be presented at the annual meeting of the Institution of British Foundrymen in June, and a member of the Institution of British Foundrymen will prepare a paper to be presented at our annual meeting. It is hoped that the number of exchanges will increase each year.

Non-Ferrous Section

During the past year a Non-ferrous section was created, and two joint sessions were arranged for with the Institute of Metals Division of the A. I. M. M. E. This arrangement proved satisfactory and it is expected that it will be continued. Our programs are now scheduled under five headings as follows: Industrial relations, gray iron and miscellaneous, steel casting, malleable casting and nonferrous.

Revision of By-Laws

At a meeting of the board of directors in Cleveland, Jan. 13, 1920, a special committee appointed by President Koch to consider revision of the by-laws reported, recommending a number of changes. The most important of these are a change

in the method of nomination and election of officers and directors, providing for the annual election by letter ballot of the members, a president and vice president to serve for one year and five directors to serve for three years; the dropping of the associate membership feature; and changing of the fiscal year from June 30 to Dec. 31. By action of the board the revised by-laws became effective at once, and copies were mailed to each of the members.

Appended hereto is the financial statement of Ernst & Ernst, who audited the books of the technical department. Their audit of the department of exhibits for the 1919 exhibit in Philadelphia and the 1920 exhibit in Columbus appears in the annual report of the board of directors.

For the aid and support given him for the past year by President C. S. Koch, Mr. W. R. Bean, chairman, and Mr. E. L. Shaner, secretary of the papers committee, Mr. Alfred E. Howell, chairman of the membership committee, the board of directors, and all his assistants the secretary-treasurer extends his warm appreciation and sincere thanks.

Respectfully submitted,

C. E. HOYT, *Secretary-Treasurer.*

Auditor's Financial Report of Technical Department

January 11th, 1920.

Mr. W. R. Bean, President,
American Foundrymen's Association, Inc.,
Chicago.

Dear Sir:—

We have completed our audit of the cash receipts and disbursements of the American Foundrymen's Association, Chicago, technical department, for the eighteen months from July 1, 1919 to Dec. 31st, 1920, and submit herewith our report.

The following is a condensed statement of the cash transactions for the period under review.

CASH BALANCE, June 30th, 1919—		
As shown by our previous report		$ 724.70
RECEIPTS—		
As per attached schedule		31,854.28
		32,578.98
DISBURSEMENTS—		
As per attached schedule		32,071.81
		507.17
Receipts from Thos. W. and J. C. Pangborn per attached schedule		2,512.50
CASH BALANCE, Dec. 31, 1920		$ 3,019.67

We compared all canceled checks returned by the bank during the period with the original disbursement entries, traced all recorded cash receipts to the bank statements on file, and reconciled the balance as shown by the books with the figures contained in signed statements received directly from the depositaries.

Appended hereto is a reconciliation of the book balance with that of the bank at Dec. 31, 1920.

In our previous report, we called attention to an item of $10.00 representing a deposit shown on the April 1919 bank statement, which amount was not entered on the books.

During the course of our audit of the records for the current period, we noted the following differences in bank deposits.

Date	Deposit per books	Deposit per bank	Difference
July 30, 1919	$181.00	$182.00	$1.00
Aug. 12, 1919	289.15	291.15	2.00

The item of $10.00 for the prior period together with the items of $1.00 and $2.00 were adjusted by us and will be found on our statement of cash receipts and disbursements under the caption of "Credit by bank not allocated."

A very thorough test was made of the cash postings to the members' accounts and no errors were noted.

In our examination of the members accounts, we noted on the accounts of F. J. Crawford and Percival Johnson the following notation:

"Reported paid and canceled check returned." As the amount involved in each instance is only $6.00, we did not attempt to trace these differences.

We attach hereto a schedule of unpaid members dues at Dec. 31, 1920 and also a schedule showing advance payments on dues for the year 1921. These figures were taken from the card record of members accounts. As the books of the association are kept on a cash receipts and disbursement basis, the foregoing figures do not appear in the trial balance at Dec. 31, 1920 which appears later in this report.

We verified the footings of all receipts and disbursements records. All disbursements were supported by original invoices or properly signed vouchers.

The Association has in its possession Liberty bonds aggregating $11,000.00 donated by the following:

S. Obermayer & Co.	$1,000.00
Mr. J. S. Seaman	5,000.00
Mr. W. H. McFadden	5,000.00
	$11,000.00

The bonds are kept in a safety deposit vault at the Harris Safe Deposit Co., Chicago, Ill., and are accessible to the secretary, Mr. C. E. Hoyt, and his assistant Miss J. Reininga. The bonds were presented for our inspection.

It is our understanding that these bonds are being held in trust and the interest derived therefrom is placed at the disposal of the board of directors in connection with awards to be made to those individuals who may devise a method or produce an invention that would in any way benefit the foundry industry.

The Thos. W. and J. C. Pangborn fund is a cash donation and as set forth in a letter dated Oct. 15, 1920, from the donors, is put wholly at the disposition of the board.

At Dec. 31, 1920 accrued interest on the Liberty bonds held in trust aggregated $77.71.

The following is a trial balance of the general ledger after the close of the banks, December 31st, 1920.

Harris Trust & Savings Bank.....	$ 120.02	
Harris Trust & Savings Bank (savings account)	2,512.50	
Superior Savings & Trust Co.	387.15	
Emblem account	40.50	
Furniture and fixtures	609.00	
Printing and stationery	423.29	
Liberty bonds in trust	11,000.00	
Thos. W. & J. C. Pangborn fund..		$ 2,512.50
S. Obermayer & Co. fund		1,000.00
J. S. Seaman fund		5,000.00
W. H. McFadden fund		5,000.00
Surplus—June 30, 1919, $1,582.57 Deficit for period under review, $2.61		1,579.96
	$15,092.46	$15,092.46

Yours very truly,

ERNST & ERNST,
Certified Public Accountants.

(SEAL)

Cash Receipts and Disbursements

The American Foundrymen's Association, Inc., Chicago
Eighteen Months Ended Dec. 31, 1920.

CASH BALANCE, June 30, 1919, as shown by our previous report		$ 724.70
TRANSACTIONS FOR THE YEAR		
Receipts		
Dues and subscription	$30,529.03	
Cost work account	1,144.41	
Interest	167.84	
Credits by bank not allocated	13.00	
Total Receipts	31,854.28	
Disbursements		
Printing and stationery	14,181.79	
Rent	1,035.00	
Salaries	5,825.00	
Stenographic and clerical expense	3,553.02	
Postage	2,369.60	
Office expense	423.05	
Membership certificates	188.13	
Dues in other association	15.00	
Discount and exchange	147.74	
Convention expense $2,506.44		
Less allowance by exhibit department 2,000.00	506.44	
Committee meeting expense	2,622.03	
Traveling expense	866.51	
Adding machine	177.00	
Office trunk	16.50	
Auditing	145.00	
Total Disbursements	$32,071.81	
DISBURSEMENTS EXCEED RECEIPTS		217.53
		507.17
Thos. W. and J. C. Pangborn fund	2,500.00	
Interest on Pangborn fund	12.50	2,512.50
CASH ON DEPOSIT DEC. 31, 1920		$3,019.67

The Foundry of the U. S. S. Prometheus, Repair Ship of the Atlantic Fleet*

By Lieut. R. F. Nourse, United States Navy

The efficiency of a fleet or of an individual ship of the navy is its ability to move when required and for long periods of time. Next in importance to the items of fuel and provisions comes the mechanical efficiency of the ship. To keep this at the highest point requires constant watchfulness and effort. While all naval vessels are equipped with facilities to do ordinary repairs and many times accomplish surprising things which do credit to their personnel, it is often desirable and necessary to receive outside aid.

This necessity is recognized by the navy department and in order to keep ships at sea for a maximum period each fleet is provided with a repair ship. Such a ship is the U. S. S. Prometheus, which is of the following dimensions: Length over all, 465 feet 10 inches; extreme breadth, 60 feet 2½ inches; normal draft, 20 feet; and displacement at 20 feet draft, 9220 tons.

Since April, 1919, this vessel has been detailed with the Atlantic battleship fleet. She was stationed at Brest, France, during the war as repair ship to destroyers, patrol boats, mine sweepers and transports basing at that port.

To give some idea of the repair facilities of the Prometheus, the writer will enumerate the machinery installed in the various shops.

Metal Working Machinery

Lathes, 24.
Milling machines, 4.
Vertical boring mill, 1.
Horizontal boring mill, 1.
Planers, 2.
Shapers, 3.
Grinders, 4.
Surface grinders, 1.
Turret lathes, 2.
Engraving machine, 1.
Vertical drill press, 6.
Radial drill, 3.
Sensitive drills, 3.
Mandrell press, 2.
Slotting machine, 1.
Power hack saw, 2.
Shear and punching machine, 1.
Forging press (150-ton), 1.

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Rolls, power, 1.
Steam hammer, 1.
Corrugating machine, 1.
Hand rolls, 2.
Hand shears, 1.
Pipe bending machine, 1.
Cornice break, 1.
Hydraulic press, 1.
Hydraulic test pump, 1.
Electric traveling cranes, 3.

Wood Working Machines

Universal wood worker, 1.
Band saw, 1.
Joiner, 1.
Combination saw, 1.
Mortice and boring machine, 1.
Wood lathe, 2.
Saw filing and setting machine, 1.
Surface planer, 1.

All of these machines are installed in the various shops on the berth and platform decks and are motor driven. We

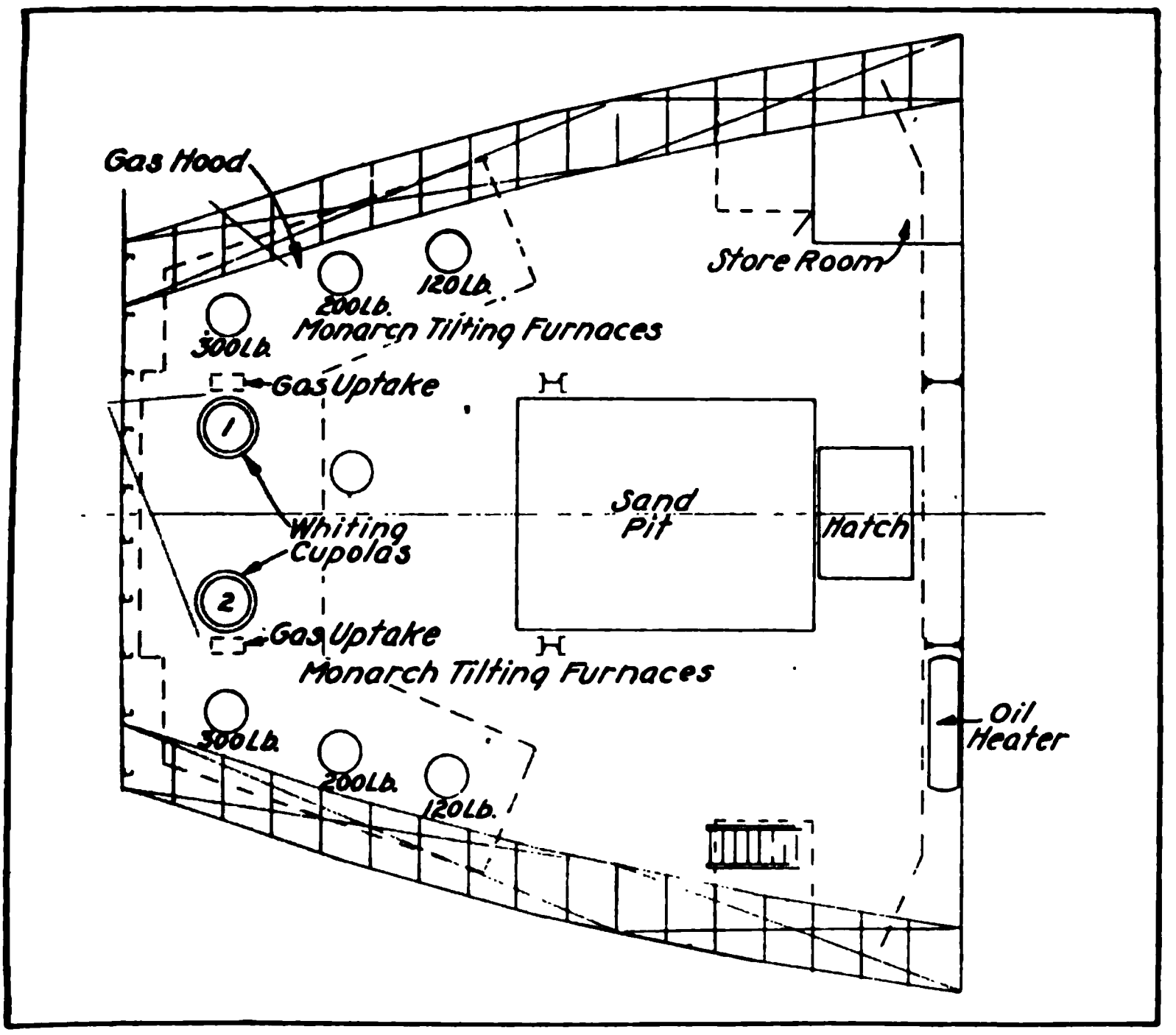

FIG. 2—ARRANGEMENT OF FOUNDRY, PLATFORM DECK

have on board an arc welding outfit and an oxygen acetylene welding shop for which there is an acetylene generator. All shops are fitted with air lines for pneumatic tools.

While all the battle ships and most of the cruisers are fitted with brass furnaces and do a large amount of small work,

in the foundry equipment the PROMETHEUS surpasses any of them. The foundry is situated in the after-hold between frames 99 and 117 and extends from the main deck down, including the berth and platform decks with store rooms underneath.

On the lower platform deck in a floor space of 1940 square feet are situated on each side toward the after end six Monarch tilting furnaces; two of 120 pounds capacity, two of 200 pounds capacity, and two of 300 pounds capacity. These furnaces are oil fired and are provided with hoods with gas escapes.

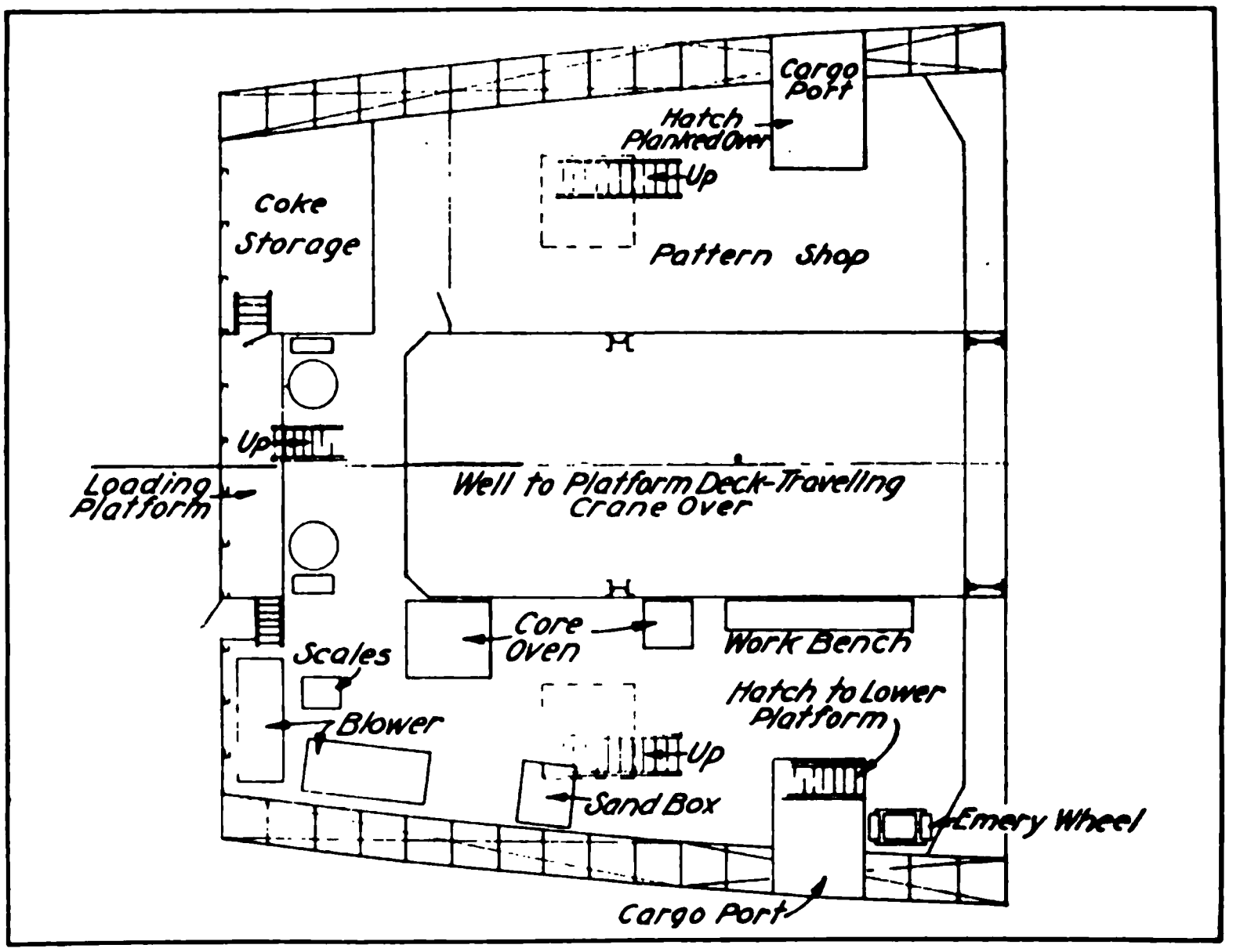

FIG. 3—PLAN OF FOUNDRY, BERTH OR GALLEY DECK

Near the center aft are three Whiting cupolas, one No. 0 of ¼ to ½-ton capacity, one No. 1 of ½ to 1 ton capacity and one No. 2 of 1 to 2 tons capacity.

Forward of the brass furnaces and cupolas is the molding floor in the center of which is a sand pit, 6½ x 14 x 18 feet, used for making large castings. The rest of the space below the platform deck and around the sand pit is used as a metal store room.

The center of the foundry is open to the main deck and

is there covered by a portable hatch which gives sufficient escape for the gases when pouring. The lower deck is ventilated by means of electric blowers.

There is a gallery extending around three sides of the foundry at a height of the berth deck. On the starboard side of this gallery are two core ovens, a work bench for the core-makers and electric blowers for the cupolas. Across the after end is the loading platform for the cupolas and on the port side but in a separate compartment is the pattern shop. This is

FIG. 4—ELEVATION OF FOUNDRY

equipped with the tools necessary in making patterns. The entire gallery has a floor space of 1750 square feet. In the hatch over the center is an electric traveling crane of 3 tons capacity which runs the entire length of the foundry.

The winches and booms on deck are used for lifting weights to the deck, and also can take anything from the lower platform deck and place it in a boat alongside the ship. These booms are of 10-ton capacity.

Output of Castings During War

While at Brest during the war the foundry reached its greatest output. The following table gives the output by months during that time:

Month—1918	No. of iron Castings	Total weight
March	156	7782
April	112	4625
May	323	17342
June	282	10177
July	261	11287
August	422	22251
September	393	20166
October	829	36078
November	1359	59589
December	1144	45090

Month—1918	No. of composition and brass castings	Total weight
March	132	1133
April	225	3295
May	384	2975
June	328	3503
July	483	4292
August	546	9075
September	810	5188
October	815	5980
November	518	4302
December	602	5979

Month—1918	No. of patterns made	No. of core boxes made
March	81	28
April	68	18
May	76	23
June	72	23
July	121	31
August	120	28
September	102	24
October	103	25
November	92	34
December	49	17

It will be noticed that in November, the month of the armistice, the output was at the maximum.

The work completed by the foundry covers a large list of castings used in marine practice, but among some of the work accomplished may be mentioned pistons, cylinders and manifolds for motor boats; pistons and slide valves; angle and globe valves; pump cylinders; valves and liners; and piston rings of all sizes. The largest casting was for a 73½-inch diameter

Americanism

By R. M. Little, New York

Americanism means certain fundamental concepts of American life. It is a word of at least four dimensions, signifying equality, liberty, opportunity and justice. Perhaps first of all Americanism means a profound belief in the worth of human life. America is a great human venture. Human life, human interests, human rights, human justice, human relations, human activities, human aspirations, human hope and human faith are the central ideas in Americanism. This nation was founded in this belief—not that we believe that all men are created equal as to their talents but that they are equal as to their rights, particularly their rights in relationship to government, their rights in relationship to the economic order, the social order, as to education and religion.

Root Ideas

Let us first consider Americanism from the governmental point of view. American people believe their government rests upon the consent of the governed. The declaration of independence, the federal constitution and all state constitutions have been established by a majority vote of the electors. The laws are enacted and administered upon the same principle. "The people" now means the men and women 21 years of age and over who are citizens. Electors include both male and female. Government resting upon the consent of the people, therefore, it is by the people and for their welfare that it exists. We believe that all men are endowed with certain inalienable rights, and among these are life, liberty and the pursuit of happiness. These inalienable rights are to be granted to all of the citizens of America and to all people who live in our country. This is a root idea of Americanism from the governmental point of view. The government is to be preserved by the people for the welfare of the individual citizen and for groups of citizens. They are assured a certain

equality before the law, in the schools, in industry and in social development. They are assured certain opportunities for self-development and self-realization, that they may enjoy the richness of life. These are governmental principles in our conception of Americanism.

Many Nationalities

Does Americanism mean the Anglo-Saxon type of national life? Perhaps most people think that it does. The Anglo-Saxons colonized the United States and led in the development of the national government, institutions, laws, manners and customs. The Anglo-Saxons are the dominant influence in the nation. In view of our national development, however, and the many types of people who have become citizens, we should not aver that Americanism is synonymous with the Anglo-Saxon conception of life. This conception may be the dominant one, but it is certainly being modified by many other types. It seems to the writer that Americanism means something broader and more inclusive than that type of life which first obtained in New England and Virginia. America is not only for the Anglo-Saxon people, but also for the liberty-loving people of other nationalities and races. If we were to resolve the question of Americanism upon the rights of priority, the Indian tribes would be more entitled to call this land their own than any of the rest of us.

This recalls an illustration of Americanism that I learned one day on the Pacific coast. We were engaged in a baseball game with an Indian tribe. I made a base hit and was attempting to steal second. The pitcher tried to catch me at the base, but I was safe. The first baseman and the pitcher were exchanging some Indian jargon as well as the ball, and I said to the baseman, "Why do you not talk the American language?" He retorted, "Why don't you?" My language was the English language; his was the original American.

Americanism is Broad

So, when we discuss the question of Americanism and what America stands for, we should not say that it is represented by the Puritans of New England alone, nor by the

Cavaliers of Virginia, nor by the descendants of both these types living about the Great Lakes, nor by the "Forty-niners" and their descendants who went to the Pacific coast. The Indians are not typical Americans, neither are the descendants of the Spaniards and Mexicans; nor are the negoes who were brought here as slaves, or the recent immigrants from south Europe. Americanism is broad enough to include the values of all these nationalities and strains of the human family. America is not for one race or one tongue, or one type of people alone. Our country is too great in its possibilities and opportunities and too inspiring in its principles and ideals to be limited to any national characteristic of the rest of the world. With a substantial basis of Anglo-Saxon ideals and principles, love of liberty, justice, morality and truth, we are developing a great nation which is to invoke and develop the highest qualities of many peoples and fuse them together with one spirit and one great purpose, but with many diversities of customs and manners.

In Drinkwater's dramatization of Lincoln there is one scene which is most impressive—that where the great American is standing looking at a map of the United States. The extent of our physical domain is the basis for empire like unto which no other people enjoys, and the other nations of the world have been pouring their life-blood into this great empire or republic. As Americans we are building stronger mansions for our souls, and all people who share in our national life are going through a process of self-realization and self-development under equal rights, equal laws and equal opportunities for the development of the larger meaning of human life. America is in the vanguard of human progress and will be for generations and perhaps centuries yet to come.

Small Americans

There have been many attempts through provincialism to limit the conception of Americanism. There has been the cry "America for the Americans!" The Know-Nothing party of half a century ago had this limited conception. There have been recurrent attempts to define Americanism according to certain colonial types. These ideas still persist and not a few

seriously wish that none but Anglo-Saxons and their close kinsman should be welcomed to our shores. This is hardly true to the genesis of Americanism. Our national life cannot be thus confined. It will not be so limited. Because of its fundamental conception of human nature, Americanism is not selfish, unjust or illiberal. Americanism is something that is deep and broad with height and reach for all of humanity. Let us free our minds, therefore, at the outset of our discussion from any petty small ideas of our country or of the people who live here, and strive together in the making of a great republic of men. An expanding view of our national life needs to be emphasized in these times, because we hear the voices of the descendants of the Puritans talking in a very small way about America and Americanism. We hear the voices of certain descendants of the old Cavaliers talking in an unworthy way of the principles of this country and its development and destiny. I am not unmindful of the great contribution which our forefathers made to America, but from my point of view I cannot think of an illiberal, selfish, exclusive America; nor do I believe in an isolated America which shall not participate in the whole life of the world. We may be properly concerned to safeguard our inheritance, conserve our strength and defend our interests, but our inheritance and our strength and our interests are not such as to cause us to be afraid to do our part among the nations of the world, to insure a larger liberty and a more complete justice and a fuller life for all other nations. The world grows and moves on and we must move forward with the tide of the world life. World events have drawn us out of our isolation and America now must play a leading part in the further progress and development of the world. Our manifest destiny is partnership and service, and we will best develop our own national life, conserve our inheritance and develop our strength, by co-operative service with other peoples.

A Nation of Pioneers

The poet of our democracy, Walt Whitman, saw America as a nation of tan-faced children, strong and venturesome, on the march, bearing the brunt of danger, nothing daunted,

nothing fearing, the youthful sinewy races, and all the races on us depending as a nation of pioneers!

"O you youths, western youths,
So impatient, full of action, full of manly pride and friendship,
Plain I see you, western youths, see you tramping with the foremost,
Pioneers! O pioneers!

Have the elder races halted?
Do they droop and end their lesson, wearied, over there beyond the seas?
We take up the task eternal, and the burden, and the lesson,
Pioneers! O pioneers!"

Typical Americans

America is still in the making, but we have had and now have many men and women who typify the principles and ideals of our country. I think of myself only as an American. My forefathers fought in the Revolutionary war in the Carolinas and Georgia. They moved north of the Mason and Dixon line because of slavery. I was born in southern Ohio, educated there and in Illinois. I have lived on the Pacific coast and on the Great Lakes, at the confluence of the Allegheny and Monongahela rivers, and near Independence Hall. I have been a sojourner in the national capital and I am now a resident of the metropolis. I see very real Americans in New York; I meet with them in New England; I know many of them in western Pennsylvania; they thrive in Chicago; they are numerous in Portland and San Francisco; and I have fellowshipped with them in Jacksonville and Memphis. They are all over our country, men and women who are typical Americans, of the same stuff that was in Abraham Lincoln and John Hay, Ulysses S. Grant and Grover Cleveland, Horace Greeley and Henry W. Grady, Ralph Waldo Emerson and Sidney Lanier, Samuel F. B. Morse and John A. Brashear, Frances E. Willard and Anna B. Shaw, Cyrus W. Field and

James J. Hill, Horace Mann and William R. Harper, Booker T. Washington and John Mitchell, Henry Ward Beecher and Theodore Roosevelt. It has been an inspiration and a delight to meet the men and women throughout our country, who share in the same principles and ideals of life which is best described by the word, Americanism. Their minds and hearts are a veritable source of truth, liberty, justice, morality and the passionate aspiration for all those values which make life sweet and satisfactory. I like to recall these splendid men and women of our country who were so rich in their sympathies, broad in their reason, energetic in their spirit, forward-looking in their endeavors, and who helped to build our national life.

Americanism and Americanization

Only as we have clear ideas of Americanism, however, can we intelligently consider Americanization. Americanization is a popular subject of the hour. It is being much discussed and many plans and methods evolved for its development. The subject is of great importance because of the large number of people in our country who were foreign-born. According to the census we have now in the United States some fifteen million people of foreign birth, one-half of whom have not yet been naturalized and about one-half of whom do not speak the English language. They live for the most part in our large cities and industrial centers and are spread widely over the northern part of our country. The question of their Americanization presses upon us in our schools, in our politics, in our government, in our religious life, and particularly in our industries.

In short, Americanization, means making good, loyal American citizens out of those in our midst who are foreign-born and many of whom speak only foreign languages. This is what we are aiming at by Americanization. The problem of Americanization is being approached from a great many different angles and by many methods. With characteristic hurry and impatience we are attempting to accomplish the task speedily, but we often fail to remember the history, the traditions, the characteristics and the instincts of the people

we would Americanize. We approach people of foreign birth and try to put a placard upon them, to perform an outward operation, that will turn them into American citizens as by magic. Too often we try to Americanize the foreign-born with a specially thought-out stereotyped process, but without fully considering the fundamental factors involved. We Americanize them by naturalization laws; we would Americanize them by teaching them the English language. We would Americanize them by having them drop their national customs and manners and adopting our own. We think they would be Americans if they were just like we are.

But something more comprehensive and fundamental is involved in the process of Americanization of people of foreign birth and speech than is attempted by any of these methods. Let us not forget that America herself has been in the process of formation since the time that the Puritan forefathers landed on Plymouth Rock. Our country is still in the making. All people who live here are changing, varied in their characteristics, although sharing certain great fundamental things together. Those who have come in recent years, whether they have been naturalized or not, have entered our country to share its life, to imbibe its spirit, and they are becoming Americans by the processes of life, assimilation, adaptation and ambition. The first step in their Americanization was their decision to come to America. This decision marked an epoch in their lives. Through many influences they learned to believe in America; to believe in it as a land of opportunity. America appealed to their imagination as a land of freedom, of hope and of promise. When they acted upon this decision and belief, they left the lands of their birth and came here, most of them to stay, and only a few hundred thousand ever to return. This was the first step in their Americanization. This step put them in a continuing process of growth and adaptation into our political activities, our principles and ideals, our institutions, customs and laws. They are here sharing in our national life and they feel the formative influences which are nation-wide in their extent, tremendous forces which affect the thought, feeling and action of foreign-born men and

women when they step upon the shores of America. Our national life appeals to them as nothing else ever did, and most of them respond to this appeal whole-heartedly and with promise. This applies, of course, to the normal men and women, not to the criminals, nor to the imbeciles and the incompetents, which are inconsiderable in number. Perhaps the administration of our immigration laws should be more rigid that all undesirable immigrants might be excluded. But their number is inconsiderable as compared to the fifteen million of foreign-born people who are now in America and who have entered into the process of becoming genuine Americans.

Right Attitude Toward Foreign-Born

What shall be the attitude of America toward the people of foreign birth. Shall it continue to be an attitude of questioning? If we expect to Americanize them we must believe in them. They believed in America and now it behooves those of us who make up the majority of the citizenship of America to believe in people of foreign birth. How can we do otherwise? Just at present it is not popular to champion their cause for the reason that the foreigner, so-called, is accused of a great deal of the public irritation and disturbance. No doubt they are unjustly accused in a great many cases. It is popular to make the foreign-born the scapegoat. But if we will carefully investigate the facts and analyze the conditions we will frequently find that it is not people of foreign birth and tongue so much as other forces which have raised the disturbance. Quite true, there are a few thousand agitators, radicals, revolutionists and bolsheviks who are attracting a great deal of attention and most of them merit the treatment they are receiving. But what are a few thousand in comparison to the nearly fifteen million law-abiding, industrious and loyal men and women from other lands who are in our midst. They are sharing our national life and doing much of our work, and in many respects they represent the youth, virility and strength of the countries from which they came. They came as vigorous young men and women to use their muscles and their brains in our industries, and while they are

concerned for their own advancement, they make a contribution to our national life which is rich with the tradition of many centuries. They came not only to do our work, but also to help sing our songs, to write our literature, to please us with their music, their manners and their customs. They help to enrich our national life and we ought to believe in them and their possibilities. Americanism first of all means a certain attitude towards human life and there has not been anything in the past of these people of foreign birth to cause us to turn aside and say that they are unworthy of belief.

There is one beautiful little spot in Washington along Pennsylvania Avenue in front of the White House called Lafayette Square. In one corner of this charming park is a statue of the Marquis of Lafayette. In another there is a statue of Kosciusko, a liberty-loving Pole, and in another a statue of Baron von Steuben, a liberty-loving German; and as you go on through the park and look at the various statues you will see typified in heroic form the men of foreign birth who fought valiantly for the foundation of America and the descendants of these patriots have largely followed in their footsteps. Let us believe in them. Furthermore we and all the people of the old American stock should divest our minds of a certain attitude of contempt for the foreigner. This is all too prevalent with us and it is being accentuated at the present time. Looking down upon the man of foreign birth ill-becomes an American who believes in liberty, equality, fraternity and square dealing. We bemean ourselves when we treat those of foreign birth and speech with contempt. We reveal our provincialism and narrowness of mind by such an attitude.

Laws and Administration

Our laws and their administration are an important factor in Americanization. The substance of our laws is just and right, but the administration of our laws is frequently not as well wrought out as the substance. The declaration of independence, the federal constitution and the constitutions of our various states and nearly all our statutes have been conceived in justice and in fairness for all the people. The foreign-

born is frequently at a loss to understand the disparity between the principles and ideals of our substantive law and the action of our police departments, police and magistrate's courts and the courts of record, nor do they well understand our legislative processes. If this is a land of liberty and justice, why is he so often treated as he is by the police and the minor courts? Why can he not more readily and cheaply secure redress from the wrongs by his landlord and his employer, or by his fellow-countryman? The processes of our courts are not adjusted to the needs of the poor man, though he is an American; much less are they adjusted to the needs of the foreign-born. There is a great national task before us to make the administration of law as just and adaptable to the needs of life as the fundamental conceptions of law are to the needs of all people. It is only within the last few years that there has been established in any place a workingman's court where he can secure substantial justice. He has always had the police court and the magistrate's court, but they are not courts of record, nor have they always been courts of justice for the poor and disadvantaged citizen. The municipal court of Chicago, the county court at Pittsburgh, the court of domestic relations at Philadelphia, and some of the courts in New York city approximate the needs of a poor man's court. But throughout the country the working man and the foreign-speaking man is often deprived of substantial justice, even though the laws underlying the courts were framed in a spirit of justice and fair dealing. If you will read the recent report issued by the Carnegie Corporation on "Justice and the Poor," you will be convinced of the fairness of this criticism.

Often the foreign-born is confused by our practical political methods. He thoroughly believes in our fundamental conception of government, but he does not understand the way we do things politically. Of course we do not have an ideal government and it is always a party government. It does not matter which party is in power or which one is seeking to come into power. As a result the foreign-born get tangled up in our politics and they are often misused and exploited, and as a result they have a wrong conception of our govern-

ment. Who is to blame? Are they, or are we Americans? Should we leave them to be instructed as to the principles and methods of our government and our politics by political workers, or should we open night schools for them where they can be instructed in civics and in our political methods?

Americanization in Public Schools

One of the greatest influences to Americanize the people of foreign birth that we have is our schools. The problem of Americanization does not apply so much to children of school age as it does to adults. Their children in the public schools have the finest influences about them for Americanization that there is in our country. There is something like democracy, life, liberty and fraternity in the school room. One of the wonders is the way the children of the foreign-born respond to the opportunities of the public schools.

An Opportunity for the Churches

What are the churches doing towards Americanizing the foreign-born? Most of them are impelled by pious wishes and good intentions, but do not understand the task they have undertaken to perform. Unfortunately, many of the churches have a narrow and sectarian view of the matter. They fail to recognize the traditions and the aptitudes of many people who come to our shores. Church organizations, as such, are not effective agencies for Americanization, except as the people of foreign birth naturally become members of these church organizations. The attempt of Protestant churches to Americanize the foreign-born from south European countries who belong to the Roman Catholic church or to the Greek Orthodox church is rarely successful. It seems to me that it would be much better to encourage the people of foreign birth to establish their own churches and to be loyal to their own religious traditions, beliefs and associations, than to try to win them to a form of church organization and worship which is to them strange and nonappealing. In America the church and the state are independent of each other. It is one of our fundamental convictions that they should be separated and that all citizens should be free to worship God according to the dictates of their consciences without anyone to molest them, and, as

our Puritan forefathers and the Cavaliers contended for this right for themselves, America should conserve this right for all people who come to this country from other lands. It is better for America that these religious units should not be meddled with and broken up. Not to welcome their loyalty to their church, their creed, their worship and their priests is a mistake.

Americanization in Industry

How can our industries help to Americanize the people of foreign birth? Work is the major interest of life; eight hours per day, at least, and often more, is the daily task of these people of foreign birth as well as for the rest of us. Where can they find what America is, and where can they find their self-realization in America if not at their jobs in our factories, in our mills, in our mines and our transportation companies? Foreign labor is indispensable to the continued growth and development of the industries of America. As their labor is indispensable it behooves the industries to give them a square deal and not exploit them, to see that they have equal treatment with everybody else. This is what they expect. Do not play upon their ignorance or fears or their prejudices, but treat them as men and women worthy of their hire and of self-respect. The industrial attitude toward the foreign-born should be one of kindness and considerate and intelligent treatment. Americanization in industry is a mutual process of give and take. We take from them and give to them; they give to us and take from us. The process is as reciprocal as life itself and is an important factor in the building up of our industries. Industrially we must understand them, believe in them and sympathize with them.

This is not always the attitude of our American industries toward the foreign-born. There comes to my mind a remark of an official in a South Chicago steel mill who said to me some time since, "I cannot do anything with these 'hunkies' unless I swear at them and occasionally throw brick bats at them." Lamentable, but true, that often the first words which the foreign-born workman has learned in a factory or mill have been words of obscenity and profanity. Who is a

"hunkey?" He may be a John Huss. Who is a "dago?" He may be a Savonarola. Oh, these epithets of contempt! In our industries let us give them a fair deal, pay them a living wage, be patient with them, try to understand them and always treat them fairly.

Many of our industries are doing a fine service in teaching the foreign-born the English language. This is an important factor in their Americanization, and one which I would emphasize and not minimize. We should not forget, however, that learning to speak the English language does not mean complete Americanization. They should learn the common language of the land where they live and work, as a means of communication, a vehicle of thought, that mind may understand mind and that work may go along more smoothly. The teaching of English is of high importance in this respect, but I am thinking of something more fundamental than acquiring a language. The process of Americanization should mean for the foreign-born the question of a new point of view, the sharing of our national life, the development of a greater loyalty to our country, its institutions, its laws and purposes. It is quite possible for them to learn the English language and yet not be Americans in this full sense. I plead, therefore, that in our attempt to Americanize the foreign-born, we try to wed them to the highest conception of Americanism.

Loyalty of Foreign-born

Some of you may think that I have been too much the champion of the foreign-born and foreign-speaking people. Let me call your attention to the fact that they have been splendid in these years of stress. True, the newspaper headlines often give them a rather sinister aspect, but newspaper headlines do not tell the whole story. What did the foreign-born do in the Liberty loan campaigns? The treasury department reports that in every Liberty loan the foreign-born fully subscribed their quota, and in the fourth Liberty loan, the foreign-born, and children of the foreign-born, subscribed 16 per cent of the loan and 46½ per cent of the subscriptions. Where a man's treasure is, there his heart is also. The hearts of fifteen million foreign-born and foreign-speaking people

were almost unanimously with America in the world struggle. What sort of soldiers did they make? Ask any of the young officers who were in France and in the thick of the fight. The foreign-born soldier did his part as a brave, loyal American. Pardon a personal reference. My son started as a lieutenant in the battle of the Argonne with a company of 250 men, many of whom were foreign-born and who could not speak the English language when they went to the camps. He returned after five days fierce fighting with but 50 per cent of his men, but never once was a foreign-born soldier a quitter. He went east of the Meuse and was engaged in the final drive with a company of 175 men until 11:15 on Armistice day; standing before a strong German position with many of his men dead and wounded about him and others still fighting, but not once did a foreign-born soldier falter or fail to do his duty. Get the inside stories from the young officers who were on the firing line and you will be thrilled with the bravery and heroism of the Italians, Hungarians, Greeks, and Poles who fought under the star spangled banner because they believed in America. We need the foreign-born people in our country and they need to imbibe the ideals and principles of our land. We need them in our social, school and religious life, and in our industrial service. There is good human stuff in them and they will make loyal and dependable Americans, as patriotic and devoted to the interests and destiny of our land as any of the rest of us. Let us try to understand and respect them, and treat them with that consideration which is in harmony with the fundamental principles of Americanism. Show to them kindness and sympathy in all the affairs of life, in our courts and in our politics, in our schools and in our industries, and then we will help to make a larger, grander and finer American nation.

Teaching English to Foreigners

By John R. Dyer, New York

Not long ago somebody defined a foreigner as "A man away from home." Several million of the best men of America were away from home during the war. They wanted a welcome—and in England and in France they found that welcome. There are 15 million Americans away from home. Yet I imagine these men who live in South Columbus, South Chicago, Gary or other industrial towns have never once been invited into American homes, and perhaps many of them are tremendously lonesome.

I sat down in a street car a little while ago and started to talk to one of these men, and we had quite a good time for a little while. He looked at me awhile and finally he said, "What are you, a Pollock?" Now I can't imagine any reason, outside of my personal appearance, for his thinking me a Pole, unless it was the fact that he could hardly believe an American would do that. I wonder how many of us are sinners in that regard.

The man who arranged for these friends referred to to come up this afternoon taught a class of foreigners in a box car at Ames, Iowa. Today he is the trusted head of this work for six or eight plants in South Columbus. Today he has more friends in these factories than any one man in Columbus. It has been a pleasure to see the way the men in the shop and in the office alike greeted him with a kindly salutation.

I simply want to make one point, and that is that winning the spirit and the good will of the men in industry is the biggest problem, the biggest job, that any man ever had. To win the friendship of these men is a work of the heart, and it can only be done by meeting them in a friendly, hearty, brotherly way, letting them know that your interest in them is real, and not assumed for production sake. It has got to be on a fifty-fifty basis.

I heard a story with which I shall close this introduction. A butcher was making what he called rabbit sausages. Some of his customers got suspicious and sent in a committee to investigate. The committee asked him what he was making and he said, "I put in rabbit meat." "Well, but don't you ever put in anything else besides rabbit meat? Don't you use something else for filler?" "Oh, well," he said, "I do use a little other meat for filler. I put in a little horse meat." "Well," the committee said, "on what basis do you mix it?" "Well," he said, "I do it on the fifty-fifty basis." They asked him what he meant by the fifty-fifty basis, and he said, "One rabbit and one horse."

Now too many of our leaders in industry have been putting it on exactly that basis, a fifty-fifty relationship with the workers, with a kind word once a week they expect the workers to have their hearts full of good will for the management. If you are going to win the good will and friendship of these men you have got to do it on some other basis than one rabbit and one horse.

The Roberts method of teaching English to foreigners is one that I am going to use this afternoon.

Note.—Following the above introduction, Mr. Dyer, in the absence of Fred H. Ringe, Y. M. C. A., New York, showed by actual demonstration how foreign born workmen can be taught simple English in a short space of time. A dozen foreigners were brought in from the plant of the Buckeye Steel Castings Co., Columbus, for the demonstration. An interpreter first explained to them the purpose of the test, after which Mr. Dyer went through the motions of awaking from sleep, opening his eyes, looking for his watch, finding his watch and seeing what time it was. After each movement he explained his act in a simple sentence as, "I awake from sleep;" "I open my eyes;" "I look for my watch;" etc. He then asked the men to repeat these sentences, one at a time, in unison. Later he had each man repeat each sentence alone. When they became proficient in this, he asked them to state the sentence corresponding to his actions, as he again went through the movements previously enacted. Similar instruction was carried on for a period of about 20 minutes and at the end 11 of the 12 men were fairly familiar with the use of the words: Awake, open, eyes, look, watch and find. Mr. Dyer explained that this method, when applied systematically over a period of time, is successful with the majority of foreign born employes.

Various Plans of Industrial Relations

HB

By Ray Vance, New York

The title of this paper is so broad that it might be considered as covering every form of contract between employer and employe. However, to restrict the discussion to the limits desired, we must consider only those definite plans by which employers have sought to obtain such a co-operative understanding with their employes as would bring about a voluntary increase of production on their part, while at the same time giving them more pleasant working conditions and larger financial returns.

Nothing could more certainly destroy the practical value of this study than to approach these plans of industrial relationship in a mental attitude of criticizing their abstract principles. We must first fix firmly in our minds the fact that industrial co-operation, while enthusiastically supported by a very large section of the industrial world, is decidedly on trial with another very important fraction of both employers and employes. Therefore, the plans must be considered not so much in the light of theoretical perfection as in the light of the every day conditions out of which they have grown. In other words, the plans are not models of theoretical perfection made outside and imposed upon the industries where they exist, but are the result of consultation, co-operation and compromise, to make them workable by the human elements already found within the industry.

Human Elements Involved

When we spread out a picture of these human elements, we must naturally consider the employer first, for it is from the employer that most of the initiative in such plans has come. Some employers have entered into their plans for industrial relationship with the broad realization that under-production is the most fundamental of all causes of poverty, because no system of dividing the product of industry between employer

and employe can avoid being limited by the amount and quality of product which is to be distributed. You cannot divide something which is not in existence. Therefore, they have realized that the first step is to secure either more intense or more intelligent effort on the part of the actual producers, so that the goods to be divided may be plentiful enough to permit a really increased standard of living on the part of producers. Such men frequently have regarded themselves merely as the leaders of their employes, rather than as capitalists, and have kept the motive of personal profit in the background.

Others—and I frankly believe a far greater number—have simply seen the proposition in this light; there is between the quantity and quality of output of indifferent, uninterested labor on the one hand, and that of active, intelligent labor on the other hand, a margin sufficiently wide to bring the employe a new standard of living, and at the same time to offer capital most exceptional profits. The motive here has been different, but the working method and results very nearly the same.

There exists, however, still a third class of employers who have been without much real belief in the efficacy of industrial relations plans, but who in spite of this lack of confidence, have installed such plans in much the same spirit that a shipwrecked sailor steps out of his small boat into a band of South Sea Islanders. He feels sure that he cannot be any worse off than he has been under the prevailing conditions. He hopes for the best, but keeps one eye open for signs of cannibalism, and if he has a gun in his possession is likely to have one hand on that.

When an employer of any one of these three types has decided to enter a plan of industrial relations with his employes much less than half of the total opposition has been overcome, for, when the employe is met, the one dominant mental reaction is suspicion. High guaranteed wages, a greater number of hours totally free from work, or guarantees that the men need not do more than a certain fixed limited task within any working day are things which the employes under-

stand and appreciate. But such phrases as "going into partnership with the boss" mean to them "speeding up" and a whole train of other bogies which they have been taught to fear.

If we were asked to consider the theoretical probabilities of introducing successful plans of co-operation into a labor situation such as has existed in the United States during the past four or five years, we might well be justified in deciding that the best of plans would be wrecked upon the suspicion existing among the men who must voluntarily accept them if they are to be successful. The plans which actually have been put to work and which we are considering in this paper, are ones which have surmounted that obstacle. That is why we must consider them in the light of conditions out of which they have grown, rather than in the light of any preconceived theories as to just what such relations ought to be.

The two most dominant conditions which industrial relation plans have faced at the outset, have been a tendency toward mutual distrust between the employer and the employe on the one hand, and on the other hand, the unescapable necessity of having more efficient production precede in point of time any increase of distribution. The realization of these two circumstances gives us the primary key to a study of the broad principles which underly the seemingly endless variety of industrial relation plans now in existence.

Voluntary Bonuses and Profit Sharing

The most obvious and apparently the earliest method of solving this difficulty was to devise some scheme by which it was not necessary to "sell the plan" to employes until after it had been demonstrated in actual practice. In this group belong those plans for industrial relations which involve profit sharing as a voluntary reward from the management, without any contract specifications except those of the ordinary terms of employment. The advantages of this scheme are:

1. It is put into actual effect without demanding a definite assent from all of the employes, or for that matter any definite assent from any single individual employe. As a matter of psychology, it is true that a man sometimes will give a real trial to such a scheme in his daily efforts, when he would absolutely balk at giving it a definite public recognition.

2. This gave to the management an opportunity to demonstrate at the end of the profit sharing period, the fact that they were honest in their promise to share profits, and were not attempting to speed up their employes through deceptive promises.

The following weaknesses of this first type of plan have developed:

1. The employe has failed to recognize any responsibility for the success or failure of the plan in whose adoption he has had no active part.

2. The connection between any increased efficiency on the part of employe and the benefit which comes to him from the plan is indirect. The average employe, particularly in one of the larger plants, is able to see very little connection between his personal efforts and the net profits of his corporation. In fact, he is apt to regard the bonus or the profit sharing payment as an arbitrary sum, fixed by the whim of the management, and, particularly in years of small profit, is likely to feel himself a victim of either greed or blundering on the part of the management, so that in the end such a plan has been judged by some of its users to create a worse feeling between employer and employe than existed before the plan went into effect.

3. The length of time likely to intervene between bonus or profit sharing payments is so long that the employe loses interest in the meantime. When he does receive it he is likely not to regard it as part of his regular income, but to use it in a spending spree, or to lose it in unwise speculation, so that neither his regular standard of living nor his saving account are improved.

Stock Selling Plans

In order to meet the weaknesses of the profit sharing scheme, two different policies have been followed by the older plans of industrial relations. One of these plans which has had a very wide use during the past 20 years is that of selling stock to employes, usually somewhat below the market price and always on easy terms of payment, arranged through the employing corporation. This plan naturally requires the assent of all employes who get any benefit from it, since the purchase of the stock requires affirmative action on the part of the employe himself. However, it has the advantage that it can be applied to any one employe without the assent of

other workers, and in theory at least, each employe who decides to participate becomes an active partner in the enterprise itself. If the corporation is a firmly established one, the employe is provided with an automatic method of accumulating a savings account, which makes him a more self respecting citizen, and usually from that very fact, a more valuable workman. This plan retains, however, the weaknesses of a very indirect connection between the employe's effort and the reward which he receives, and also the further weakness that the time intervening between payments is so long as to allow a considerable lapse in interest. Two additional weaknesses are developed in that the employe is rarely able to accumulate a sufficient number of shares of stock to make any very appreciable addition to his income, and in the second place, if the business is of a speculative nature the employe may be led to take speculative chances beyond those which should be taken with his savings.

In the last analysis, the stock selling plan of industrial relationship finds its main weaknesses in the fact that it usually affects only a minority of employes, and that its effect upon them is in a much smaller degree than was hoped by most corporations at the time of its adoption. It has, however, been considered too valuable to drop by such concerns as the United States Steel Corp. and the International Harvester Co., and has been adopted more recently by other concerns such as the Larkin Co., after a detailed study of the field. So far as I have been able to determine, it is the only plan of industrial relations in general practice which makes definite provision to assist the employe in the accumulation of capital directly under his own ownership. For that reason alone it is worth serious consideration, and this phase has led a number of concerns which follow other plans of industrial relations within their plant to adopt the selling of their company's shares to employes as a supplementary activity.

Specific Bonus Plans

A much more direct way of meeting the objections to the ordinary bonus or profit sharing scheme is involved in

those plans where bonuses are made directly dependent upon personal efforts of the employes. Specifically, this type of bonus may be based upon almost any item in which the individual employe raises his efficiency above the prevailing standard. In some industrial plants bonuses are given for extra quantity of work performed within a given space of time, but this is one of the least frequent measures, and is condemned by many as tending to produce speed at the expense of quality. More common and more generally approved bases of bonus payments are: Regularity of attendance on work; length of service; high percentage of perfect production units turned out; saving of waste material, etc. This is not a complete list, but may be taken as a sample of how the employe renders himself a more efficient producer, and thereby directly connects his own voluntary efforts with the receipt of additional compensation.

This form of direct bonus for efficiency in work has the further advantage that it can be calculated over short periods so that the employe has before him a direct reward for his own effort with very little fear that his efforts will be nullified by others over whose efforts he has no control, and at the same time receive this extra compensation with sufficient frequency to keep the interest constantly in mind. In other words, by putting bonus payments on such a basis, we eliminate the weaknesses of the ordinary bonus system which arise from indirect connection between effort and reward, and from long periods between payments.

The plans which belong to this group are being applied today in at least hundreds and possibly in thousands of industrial and transportation companies, and it is worthy of note that where more complicated plans of industrial relations have recently been adopted, the elements of this relatively simple plan have usually been retained.

The Newer Plans

The plans covered up to this point all have two characteristics in common. First, they are adopted by the management; the employe adopts or rejects the plan as a

whole. Second, the owners and managers of the business retain absolute control of all matters of business policy and of production plans.

We have noted how each of the plans of this type develop some strong points and some weak points, but in each case the effect of the plan on employes was far less than had been hoped. During the late war there arose two new groups of industrial relationship plans marked by a departure which may well be described as revolutionary. This departure involved the surrender by the management of a very considerable share in the actual distribution and production policies and in factory discipline.

The purpose of this revolutionary step is to meet the general weakness of lack of interest on the part of employes shown in the older plans of industrial relations. In studying the question I have found employers and employment managers with every shade of opinion, from most enthusiastic endorsement to the most bitter denunciation of this step, and shall make no attempt to introduce any controversial discussion as to its wisdom, but rather, confine myself to a description of how the basic principle has been applied in various plans.

Generally speaking, all the plans which involve some surrender of the power of the management to the rank and file of employes seem to group themselves under two heads:

1. Organizations which are called "industrial democracies."
2. The shop committee plan.

Industrial Democracy

So far, the industrial democracy systems are practically the work of one man, and therefore, present very little variation in type of organization. They are fully described in a book published by the author of this scheme, and I shall not attempt to reproduce that work here, but only to give a brief outline of what the plan entails.

In form, the organization is very close to that of the

representative government maintained in England or in the United States, although not a strict parallel with either. The three functioning bodies are:

1. The *Cabinet,* which consists of the major executive officers of the company, who are absolutely the representatives of the owners of the business. They have the power of veto over all actions taken by employes' representatives, and may suggest to the employes' representatives, actions which they believe should be taken, but give up their power to frame and issue any order affecting the employes without the consent of the employes' representatives.

2. The *Senate,* which is also representative of the management, in that it is made up of minor executives, department heads and foremen, appointed by the management rather than elected by the employe. This body has the right to initiate legislation regarding factory management, and passes upon all bills initiated by the employes' representatives before they go to the cabinet. Briefly stated, its powers are very similar to those of the senate in the United States government, but it should be noted that it differs in not being a directly elected body.

3. The *House of Representatives* is elected by direct secret ballot from the entire body of workers. Some variations are introduced into the plan here, since each representative may stand for a department, a section, or any other particular group of workers, but the underlying object is to make them most fully and broadly representative of the rank and file of employes. This body may either initiate legislation itself, pass upon measures initiated by the senate, or take up suggestions made by the cabinet. Briefly, its direct object is to make every worker in the company, through his direct representative, a constructive and responsible unit, in the determination of factory and producing policies.

It will be noted that this plan carries with it the theoretical possibilities of an absolute deadlock on any policy. This might result in a strike, just as would the demand of union when refused by the management of any company. In other words, its success depends upon the ability of the different human elements involved to come to a compromise agreement. In none of the plans that I have seen, is there a provision for outside arbitration of such a dispute. Frankly,

it still remains to be seen whether these plans will work out over a long period, but, up to date, I cannot find any instance where the plan once installed, has resulted in any deadlock requiring outside assistance to settle. * In two cases, however, industrial democracy plans have been allowed to lapse.

It is necessary in every one of these plans of industrial democracy that there must be some method for allowing the employe to share in the savings introduced by his voluntary co-operation in better production. I cannot see that there is any reason why any one of the bonus or profit sharing schemes mentioned earlier in this paper could not be combined with the industrial democracy plan of factory organization, but the plans installed under this method have all used a form of bonus which is called the "collective economy dividend." This dividend is not based upon the specific efficiency shown by an individual, as so many of the direct bonus plans are, but rather upon the accomplishment of the factory employes as a whole, including the rank and file, foremen and executives. It is not, however, dependent upon the net profits.

The basis of the economy dividend is the unit cost of production. Unit costs of some standard period (usually just before the plan is started) are taken as a standard, and the difference between these costs and those shown under the industrial democracy organization is considered as a collective saving, due to the co-operative efforts of the human factors in the production. Any saving made by the introduction of better machinery or better methods are included just the same as those due to more efficient use of time, for the object is to hire all the constructive brains of the employes, as well as their physical workmanship. When the collective saving has been determined, a dividend is made, one-half to capital and one-half to employes. This collective economy dividend is distributed at frequent intervals (usually two weeks) so that it carries all the benefits of constant interest on the part of the employes. It may be objected that the individual has not so great a reason for connecting this dividend with his own personal efficiency, as he has when a bonus for individual

*Since this was written several strikes actually have developed.

excellence is granted, but proponents of this plan argue that since each individual is able, through the house of representatives, to participate in the planning of policies and in the discipline under which all employes work, the connection is direct enough to answer the same purpose. It is further argued that the public opinion of the other employes will tend to exert pressure upon those few who might not be willing to give their very best efforts in order to earn an individual bonus.

Shop Committee Plans

The shop committee plans of industrial relationship are more numerous than industrial democracy plans, and, being the work of a great number of different authors, they present much wider variations. As a matter of fact, the line between company unions, employe brotherhoods, welfare societies, etc., on the one hand, and shop committees on the other hand, is not very definitely drawn. Many of the welfare organizations have gradually merged into real shop committees, and a very large percentage of the present day shop committees still function as welfare organizations, insurance societies, etc., or if created primarily for shop committees, have added those functions. However, the most generally accepted definition of a shop committee is "a group of company employes' and management's representatives (usually having an equal number of votes) meeting regularly or upon occasion, to settle joint problems."

The surrender of power by the management is a feature of these real shop committee systems. The most general provision for this surrender of power is the agreement by the management to carry out every policy which secures a unanimous vote in a joint meeting between their representatives and those of the employes. In each of the plans which I have studied, there is some provision made for an appeal where agreement cannot be reached in the first meeting. These appeals go upward until many of them end with a definite provision for carrying the case of disagreement to an outside board of arbitrators. In other words, they are intended to

completely eliminate any chance for a disagreement ending in a strike. The attitude toward outside arbitration may well be illustrated by the fact that out of 20 plans specially studied, 10 provided definitely for outside arbitration. One provided for outside mediators, and nine left to ultimate settlement inside the company itself, as is done in the case of industrial democracy plans already described.

Because of this surrender of the power of management, employers entering into shop committee plans have usually demanded three safeguards for their interests:

1. Only employes who have worked a specified time (from three months upward) are allowed to vote on the plans.
2. The right to discharge employes for certain or specific offenses without reference to the shop committee has been reserved.
3. The right to terminate the plan upon some specific notice has been reserved in a few cases. It appears to be implied in those where it is not specifically mentioned.

These three safeguards are not universal in the plans, but I should judge from comment, that they are likely to become a working part of the vast majority.

Generally speaking, the shop committee plans have the same ultimate object as those of the industrial democracy plans. That is, to make every employe a responsible unit who has an officially recognized duty in promoting the efficiency of the plant in which he works. However, no definite profit sharing bonus or wage dividend plan can be regarded as an integral and necessary part of a shop committee plan. A large majority of the individual companies which maintain these shop committee plans do have with them some one of the forms of profit sharing bonuses or wage dividends described earlier in this paper, and in all cases whether a definite profit sharing bonus or wage dividend plan is in force or not, the subject of wages and methods of wage payments are among those covered by the shop committee machinery. The point to be emphasized here is that the shop committee plan, in itself, is absolutely distinct from any one of the wage payment methods, so that anyone considering the adoption of a

full plan of industrial relationship, including both machinery for the employes' co-operation, and a method of insuring to the employe a just share of the savings or increased profits produced, will necessarily consider these things under two separate heads.

Summary

As a summary, it seems that the various plans of industrial relations can be taken under two heads:

1. Those older plans such as bonuses, stock selling plans and profit sharing schemes, which had for their object, securing more efficient co-operation from employes through offering financial rewards for efficiency, but did not in any definite way place responsibility upon the employe for production management policies.

2. The newer plans are most largely concerned with placing definite responsibility upon the employe, and, in so doing, surrender part of the power of management formerly vested in executives only. These plans in their practical working seem to demand some sort of profit sharing or wage dividend scheme to complete the appeal to the employe's self interest.

The plans under the first head have been in use long enough to be fairly well tested, and their points of weakness and strength well recognized. Those under the second head are still in the experimental stage, for they have never gone through a period when labor was not scarce and wages and profits both high.

The writer has not sought in this paper to hold a brief for any particular plan, nor does he feel competent to pass final judgment, but the possibilities of improved production are so great, and the need for more efficient production so self evident in our present industrial system, that I feel justified in saying that even the newest experiments have fully paid for themselves, and that the principles involved open up a whole new era of production management.

Industrial Relations Departments

By James W. Brown, Milwaukee

Primarily the subject of industrial relations departments has nothing to do with production, but the influence of such a department should become manifest eventually in the way of a more harmonious relation among the men and a more loyal as well as a more productive organization. Without exception, every sane manufacturer will agree that there is a real opportunity and also a real need for a more earnest effort toward bringing greater harmony into the relations between manufacturing concerns and the people associated with them. The enormous development of these concerns adds much to the perplexity of the subject and multiplies the chances for misunderstanding between men and concerns.

The industrial relations department should be clearly placed as to its relative position in the organization. It should be separate and distinct from any production department or production superintendent, and should be free to approach the worker, the foreman and the superintendent without being responsible to, or having authority over either. The department should be a free lance, so to speak. It should act as an aid and counsel for each and an attorney for the defense wherever necessary. It should be considered as having a higher purpose than merely the direct money return, for we cannot expect to hold men's confidence unless we can command their respect, ond only those whose example is uplifting and whose works are for the betterment of mankind, can hope to command the respect of their fellowmen.

Results are Well Worth Cost

Experience has convinced me that there is a money return from these efforts and that they pay a splendid return in the way of a more brotherly feeling among the people employed and a much more active interest in the success of the concern.

The oft repeated biblical question, "Am I my brother's keeper?" may not be open to an unqualified affirmative answer.

but we are evading our responsibility as members of a human family if we cannot most emphatically answer, "I *am* my brother's *brother*."

An industrial relation department calls for a peculiar combination of qualities in the guiding head. First and foremost we believe that the head of such a department should be a man of long shop experience, long enough to appreciate the viewpoints of the workman, his joys and his hopes, his plans and his ambitions. He should be intensely human in his thought of the needs of the people of his industrial family. He should be quick to meet men and listen to their side and be able to lead them to viewing all matters in a fair minded manner. Patience with foremen as well as workers is an absolute essential.

The effort of industrial relations departments should be an active influence toward proper environments, proper opportunities and proper compensation, and the avenues of effort leading to these ends are so varied and numerous that the writer prefers to be specific as to a few viewpoints rather than to generalize entirely.

Selecting the Right Men

Environments start with the employment office in selecting the right man for the task. That office should be supplied with the information as to just what sort of a man is required for each machine or job and these machines or jobs should be numbered and charted as to character of work. For instance, Job No. 45 is a plain air squeezer molding machine making small malleable chain belt links, 36 to 48 links in a mold and an equal number of cores to set. The molds are light, and there is not much iron to carry. The chart should contain this information, and should specify that the man for this job should be a light, active man whose experience had been on light work. Job No. 150 is a 20-inch engine lathe used to bore sprocket wheels on and using size cutters for both roughing and finishing. This job requires a young man with very little experience in running a lathe. The chart furnished the employment department should contain all of this information. The call would be made for "malleable molders" for Job No. 45 and for

"machine men" for machine shop work in the case of Job No. 150. The interviewer in the employment department, by adroit and clever questioning should have no difficulty in learning which applicant is best fitted for each job he has to fill without the applicant knowing just what kind of a job is really open. Most men will elaborate upon their own qualities and fitness for any certain job if they are desirous of that particular job or are anxious to start with any particular concern. We feel that this is the scientific method to follow in selecting men.

Familiarizing the Man with His Job

After selection, men should be properly introduced in their department and here, the writer believes, is a much neglected opportunity, for statistics show that the greatest percentage of turnover occurs in the first week of employment. A new entrant should be taken in hand by the foreman and introduced to his fellow workmen to make him understand that he has joined an industrial family and that he is accepted as a member of such. He should be shown the place his clothes are to be hung and the machine or bench he is to work on, as well as having the character of his work explained to him. He should then be introduced to the instructor who should make it plain to him that any information he may wish or any tools or supplies he may require or any help he might need, will be gladly furnished at any time. Besides all this, the instructor should make it his business to go to the new man frequently during the first few days to see that he has the things that will enable him to do his work efficiently as though he had been a member of the organization for a longer time. We know this pays real returns because we have tried this out in our own malleable foundry, after a long experience with the old barbarous method of putting a man in and letting him overcome the handicaps of the antagonism of a number of his fellow workmen who have been previously introduced in the same unscientific manner.

The matter of good living conditions in factories should be given sensible attention, for it is nonsensical to expect a man to be contented with his employment when toilet facilities are filthy and insufficient, when wash rooms are repulsive, when

no clean provision is made for hanging street clothes, when ventilation and light are improper and heat in winter is insufficient.

The industrial relations department has much to do with the intellectual as well as the material man, and with his peace of mind and happiness. The valuable, dependable, efficient man is the happy contented man who enjoys his work, his associates and his concern.

One of the avenues of effort of the industrial relations department should be the furtherance of safety measures. We know of no one thing that more completely paralyzes men's confidence in their concern than to see their fellowmen handicapped in their earning capacity by the negligence of the concern in failing to protect men against dangerous conditions and practices.

Promoting the "Family" Spirit

The matter of clubs should receive much attention, for clubs furnish a splendid opportunity to develop the "industrial family" spirit in the organization. It is far better for the men of a concern to belong to a club whose aims and ideals are in harmony with the policies of their concern than that they should belong to an organization whose sole aim is to influence their relations with their employer through fear.

The company with which the writer is identified has a club for salesmen, superintendents, foremen and others which does much to unify the organization and develop the get-together spirit. We believe that if we can eat together and play together harmoniously, we surely can work together. A mutual relief association is being developed into a club for the rank and file of the organization so that all of the men can get together and discuss subjects of mutual interest.

The girls of an organization should have their own club and be apart and separate from other clubs. Their amusements often are along different lines than in the other clubs, and moreover, as a rule they do not care to listen to technical talks that are so interesting to men. The main reason for a separate girls' club is that the club gives an opportunity for working out problems of caring for, and the guidance of the girls

who come into the industrial family which an association with the older and more sensible girls can give.

Reward for Permanency

The men who have been with a concern for a long period of time deserve especial recognition because of the permanency of their service, and for such the company has its "Quarter Century" club. These men who were with the concern during the years that the business was being built up, had much to do with the making of a product that could be advertised and marketed and a reputation established out of which a future greater business could be developed. In recognition of their effort the club has been organized, and suitable badges certifying as to their membership given them. We are careful to explain to them that while we recognize the great service they have rendered in the past there is still a greater one they can perform in the influence they can give to the whole organization by their example of permanency and loyalty to our concern. Particular pains are taken to emphasize this point to them and to all employes. The badge given them to wear is a lettered gold shield. Members who have completed 15 years service are entitled to a red stone setting in the badge; those who have completed 20 years service a blue stone and those who have been with the concern 25 years have a diamond set in the badge. Both hourly and piece rate men who are members feel a great satisfaction in this graceful recognition of their long service with the company.

Another measure of encouragement in permanency of service is a birthday card which is sent to all employes who have been with the company two years or more. We send a tastefully gotten up printed greeting, but great care is taken to write a personal note in addition to the printing in order to get the thought to the whole family circle that we are personally interested in each and every one who is a member of our industrial family.

It is felt that the greatest recognition of permanency of employment lies in the vacation plan, which gives to all men who are not foremen but who have been with the firm the full term of three years ending Oct. 1 of any year a full

week's vacation with the amount of pay they have averaged per week for the previous three months, regardless of whether they have been working piece work or day work. The management believes that a molder who has worked nine or ten hours a day year after year is entitled to a vacation as much as men who have been working less hours and under far more comfortable conditions. We can understand the irritation that a molder must feel to have to listen to a clerk or a timekeeper tell of the wonderful time he has had on his vacation, with pay. It is thought that this vacation plan pays the company in renewed effort and happier attitudes because the men come back telling of what a splendid time they have had and how their wives enjoyed the vacation with them. We hear such expressions as: "That was the first vacation I ever really enjoyed because I knew I was drawing my pay just the same," and "My wife says I must be working for a pretty good concern to be given a vacation with pay," etc. We make an effort to see the men before they go on their vacation in order to help them make it a real one, and to dissuade them from spending the week painting their homes or building new concrete steps or doing something that will probably so both them and their families of the vacation they all richly deserve.

Helping Men to Better Jobs

One might go on writing on environments indefinitely but the thought ought to be that men are happier when they are given to understand that the personal touch between men and concerns is ever present and operative. An important office of the industrial relations department should be to search out the men in all the different departments who show ability and help prepare them for the next better job, so that they will be ready when that job presents itself. Good men are liable to be so hidden in a job, just because they do it well, that a foreman dislikes letting them go. Advancement in an organization serves to make more apparent the fact that opportunity is ready and waiting for any and all who will make the effort to fit themselves for better jobs, and is-

urages the thought, often expressed, that there is no chance get ahead.

As an aid to the development of employes, considerable tention is paid to schools and classes. An "office school" planned to furnish instruction to the sales force and other fice people. This is designed to enlighten them as to proper isiness methods and as to our own product. A speaker is ought in to talk on some business subject for the first part the evening. This is followed by a short "get-together" cess, after which some one from our own organization gives careful explanation of the construction, development and e of some one line of our product.

Classes for Training Foremen

The classes for foremen are planned to bring to them the st knowledge available regarding the satisfactory handling men and materials. In this school text-books and lesson leets are furnished, somewhat similar to the correspondence hool course, and in addition semimonthly lectures are given a hired authority on the subjects treated by the text books. hese schools pay because they enable the company to develop to foremen the men who are trained and experienced in our n particular line of work.

For the men who are foreign born and feel the need more schooling in the English language as well as in the er elementary lines, Americanization classes are provided. ese classes among the workmen not only do much along cational lines but it is found that the men who attend se classes have a kindlier attitude toward the foremen l among themselves because of the attention they have eived in the class rooms. We feel they pay well from t standpoint alone.

In some departments, notably the malleable iron foundry, tions of the shop are set apart for beginners' schools. e plan is to keep the molder apprentices separate from journeyman molders and under the supervision and care competent instructors who teach them the proper way of h operation and the reasons why. At stated intervals the

apprentices are taken through different departments to follow up the castings they have made. We are convinced that this effort pays because we have graduated nearly 50 molders from our schools in the last nine months.

One phase of all the club and school effort that is not fully appreciated is the value of "association." All men profit by the interchange of thought and experience and shop workers are no exception. Association makes men more receptive to new thoughts and ideas.

Comparisons Show Value of Work

Many concerns are slow to do the things that make men happier and more contented because the success of these efforts are difficult to figure in dollars and cents. We know that these things pay because we can compare our organization with others that do nothing along these lines and also with our own before we had done very much. The comparisons show wherein our efforts have resulted in a more unified organization which means a more successful organization and a happier industrial family.

In this, as in any other problem, we should keep definitely in mind the end we wish to accomplish. We are striving to establish a mutual confidence between employer and employe and to bring all to understand that the success of the concern means the success of all associated with it. We are convinced that the methods discussed in the foregoing paper are bringing about these results.

Industrial Relations

By Meyer Bloomfield, Boston

There is need for sharp definition in dealing with the subject that we vaguely call industrial relations. This subject is made to mean so many different things and is looked at from so many angles that we cannot escape a feeling of confusion. This is not wholly the fault of any individual and although some may deal with it with an air of finality, the truth is that the subject itself must remain for a long time incapable of mathematical exactness of statement.

The reason for this is that "industrial relations" is another way of saying "human relations," and although we can agree on a program of principles, which in the abstract commend themselves to the common run of men, in their concrete application we are faced with about as many complications as there are human beings and interests involved. Who of us will question that justice should be the keystone of our dealings with one another? Yet in concrete cases, opinions differ. The courts would go out of business if we were all of one mind as to what justice is in specific instances.

Phrases Breed Distrust

If we believe in American institutions, we believe in democracy. We expect our political life to voice the general will of the people. In theory we say that it does; in actual fact, very often it is the decision of one man that turns the scale or fixes the policy. All the people do not govern themselves all the time in our democracy. Because political democracy yet has so far to go before it fulfills its own definition, we distrust those who glibly use the phrase "industrial democracy," suggestive though this phrase may be.

Every practical judgment reacts against the picture of our industries being conducted with the inefficiencies that we have not yet learned to control, let alone banish, from our political organization. We have so much yet to learn about

self government that we do not wonder at the rather steady succession of failures that have attended the experiment of so-called self-governing workshops. Those who preach this type of workshop as the solution of all our industrial evils, idealists though they may be, are ignorant of the history of these undertakings. Co-operation is one of the most vital of all human ideas, and has before it the most promising future in industry of any suggestion that I know anything about. But the records show that though co-operation by consumers has met with tremendous success, co-operation in production, in terms of so-called self-managed shops or industries, has failed disastrously.

Realities Versus Theories

What is the reason for this? The explanation is to be found in the failure to distinguish between the realities of sound management and the theories which have to do with questions of ownership and control.

Labor has been the principal sufferer from this confusion. Looking back a number of years we find a see-saw in the labor world between what is called direct action and action through political measures. We find this swing most marked in the English industrial world.

American industrial executives have made no more important contribution than in building up the program of management. Industrial relations is a phase of management—beyond doubt its biggest and most vital phase; or we may say, industrial management is a phase of industrial relations. By industrial relations, I mean the program of day-by-day contacts between the management and the working force.

Each Problem Has Own Solution

The labor problem, or rather the labor problems, for there is no simple, single labor problem any more than there is any simple, single solution, has to do with the general policies of final ownership and control. These are problems for all industry, for government, and for society to deal with. Industrial relations has to do with the internal human operations of the plant or the industry. A pro-

gram of industrial relations for one concern or an industry, may be wholly impractical and unworkable in another concern or industry.

This program may be narrow or broad, wise or unwise, but it is a program, if it deserves the name at all, that must grow out of the peculiar needs and conditions of the particular shop or industry. If this program does not grow out of these felt needs and known conditions, it is not a program of industrial relations and you may be sure that it will not function as such. There may be a certain amount of showy window dressing, a lot of self-deception, and a tiding over for the time being, but responsible executives will not long put up, nor will the men, with industrial relations activities that are not native to the soil, as it were.

Two conclusions follow from this statement, if there be any truth in it at all. One is that if you want an industrial relations program that will work, make sure that you develop your own brand. Moreover, if you want your own successful industrial relations plan, be sure that you really know the big facts about your organization and your men.

Getting Facts is Difficult

The hardest thing in the world to get is the truth. Not that men are untruthful, but because getting facts is no easy matter, as every manager knows from costly experience.

If you could, say every six months, make as good a human inventory in your plant as you make of your stock, you would insure your good will solvency as you do your financial solvency. General impressions about your working force are no more reliable than are general impressions about your finances. The biggest waste in industry today is the failure to utilize the productive good will of which the American workman is so richly capable of contributing. The biggest tragedy in industrial relations is the souring of that good will by unwise, because misinformed, policy.

Know Your Men

The slogan, "Know Your Own Men," is the first step in industrial relations. How can we know our men? May I point out how not to know them? Put up a barrier between

yourself and the men, expect them to take the hurdles of a number of minor executives and officials before they can communicate with you, or leave them dumb, and rely on some one to tell you about them, and you have made certain that there can be no free exchange of confidences between you and them. What they should first tell you, to your great profit and advantage, they will tell to outsiders who are their sympathizers but not your sympathizers. Who wants a condition such as this?

This condition is neither desirable nor is it necessary. It always is manufactured. The so-called trouble maker does not manufacture it; he merely takes advantage of its presence and multiplies its mischief.

The choice before the employer today is either to bring about a genuine condition of teamwork, mutual confidence and production based on an acknowledged identity of interest between the producing parties, or to let the spirit of the dogfight take possession. In the one case we have industrial relations worth the name; in the other we make of industry a prize ring or an armed camp.

The things that need to be done are not mysteries; they are being done with success throughout the plants and industries of the country. They do not always bring the peace the industry needs, but they make adjustments possible because of the good spirit which they breed. More and more adjustments will be made, because human relations do not stand still. The important thing is to have these adjustments come in the spirit of give-and-take, and not in that of belligerents.

There are those who want just such warlike situations. They are the workers' greatest menace, for nobody can throw a monkey wrench into industry without making the wage earner pay for it most and longest.

Knowing Men is Conserving Assets

To know your men, you must make sure that you genuinely want to know them, not only because it is good business to do so, but because they are members of your industrial family. Your co-workers, like your fellow-managers, are the big assets of your business, and a program of industrial relations is always

based on the desire to conserve these assets. To this end the personnel policy, that is the entire employment scheme, including the way of recruiting, hiring, placing and training, building and supervising these assets, is far-reaching in its effects. This personnel policy, and all the other policies that go under the heading of industrial relations flow from your human inventory.

"Sell" Your Policy to Men

The purpose of the inventory is not only to tell you in a systematic manner what you want to know about the human side of your organization, but to enable you to "sell" your policy to all your staff, right down the line. If any executive or employe is not "sold," by that much you have an obstruction to your plan.

A good deal of industrial friction starts smoldering in out of the way corners, just as fires do not usually begin in the open. For this reason every subordinate who has to do with giving orders or instructions must be tuned up to some recognized plant policy in dealing with the men. This cannot be brought about by general orders. It is a matter of persistent education of the whole executive force down to sub-subforemen and the guard at the gate.

Good Relations are Worth Price

Right industrial relations cost something. They cannot be had by wishing or sentimentalizing. They call for something of the same engineering process to bring about that you use in planning your equipment, sales and your manufacturing policy. But the result is worth the price. On nothing is time better spent than in analyzing the human friction spots in an organization and contriving to make the employment relation a source of satisfaction to all concerned. The power to do this lies with management. Where management accepts this responsibility it finds, despite the ups and downs that are inevitable, good reason to continue and even enlarge its efforts in this direction.

The writer is proposing no panacea. I am not telling you to do a certain thing in order to be saved. I am suggesting that you undertake a serious first-hand and systematic human fact-collecting campaign, and on the basis of what you discover

start an industrial relations program that is best, tentatively at least, for your own organization. Time will make the needed corrections and an open mind will point the way to better and better measures of mutual service.

There can be no doubt, knowing the quality of the American workingman and the American executive, that a serious dedication on the part of the executive to the constructive policies of relationship between the management and the men, possible to those who are willing to give the time and thought required, will result in tangible benefit to all concerned.

Discussion

MR. DAVID BLACK—Mr. Bloomfield mentioned the fact that it is the duty of the executives to get close to their men and know the situation from their viewpoint. In a shop of a few dozen men that would be a comparatively easy thing, but as the personnel of the employing force increases in numbers it seems to me it is a more difficult one to accomplish. To be of any value at all it must be accomplished in a manner to secure facts; otherwise the executive is no better off after he has gone through his analysis than he was in the first place. I would like to know how he suggests that the executive should go about that very thing.

MR. BLOOMFIELD—In the first place I knew perfectly well that one of the thoughts which will come to anybody's mind is, "That is all well and good if we were all in the village stage of industry, where we call each other by the first names, go to church together, etc., but those good old days are gone. Now how about modern city industry, with its suburbs and the busy man at the top who has other things to do than shaking hands with his fellows?"

We realize that the president of the company doesn't go to lunch or dinner or doesn't live in the same neighborhood with his men, though I must say that I know executives, presidents and general managers of organizations employing 7000 or 8000 workers who know a great many of their men, in the real old-fashioned way because they are living the lives of their men and are part of the community. To be sure, that proposition is rarer than it was.

The Development of Foremen

By M. C. Evans, Chicago.

It would be absolutely untrue if I should state that the foremen of today are entirely unqualified for their jobs and that some drastic reform must begin immediately to correct such a condition. It would be equally untrue to say that they are all perfect because the assumption is that there is room for improvement in all of us.

I am sympathetic with the average foreman of today who I believe is often misunderstood and who often has sterling qualities which are under-rated. His position in the past has been one wherein he has had to think principally in terms of production, quality, and cost, with very little thought of the personnel problems that are so important today. Formerly he arrived at his position after many years of training in the shop.

The Rise of the Foreman

He went from apprenticeship to a master workman, and then, due to the fact that he was a superior workman, he became assistant foreman and finally foreman of the department. He was often referred to as "Boss" and his word was taken as law by those who worked under him. Such a man earned his promotion through sheer ability to do his job better than the other fellow, but often, however, proved to be an absolute failure as foreman of a department.

The average foreman is beginning to realize that a trained mind is perhaps the most important qualification for success in the industrial world; a general realization of this will give us a basis for the training of any man in an industrial concern. It is true that often men become highly skilled and trained in their professions, that keen competition comes, and that a few rise above the others to positions of high importance in the company. This naturally has a tendency toward upgrading and a higher standard of organization will naturally tend to put any company in the lead in spite of competition.

Present industrial conditions, with the difficulties which confront the foreman, have made him study and he has for the most part developed a real desire to obtain information about better ways of handling his own job. Whether he utters it or not, the question in his mind is, "How does the other fellow do it?" In confidential talks foremen have often told us that they wish they had had the opportunities of the boys today for an education.

Foreman Represents Company

My sympathies are with the foremen. I believe that in the past many companies have failed to recognize the true value of the most important man in their producing organization—the foreman. To the workman in the shop the foreman is the company, and through him they learn the policies and wishes of the management. Their respect and loyalty for the company will gain with the good salesmanship of the foreman.

Many foremen have the feeling that they are not really a part of the management of the company. Where they have this consciousness, it is certain that they are not able to transmit properly the attitude, views and policies of the company to the working men, and this, after all, is one of the most important duties of any foreman—to be the man in between the working man and the management. He has been rightfully called the key-man in industry. And if he is the key-man in industry, can we imagine that time is wasted in training him so that he will properly represent the management to the men, or on the other hand, reflect to the management the attitude of the men under him? Anything that will help to strengthen the foremen in this relation should be encouraged.

In my estimation, some of the characteristics necessary for good foremanship today may be classified under the following headings:

(a) The foreman should have leadership and personality.

(b) He should be a keen student of human nature.

(c) He should have a knowledge of company policies and ability in order to properly transmit them to his men.

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(d) Also knowledge of his work and methods of manufacture.

(e) And knowledge of methods outside of his own company.

(f) He should be able to instill a spirit of co-operation in his department.

(g) He should favor the development of understudies.

Conducts Foremen's Training Course

It would be easy to spend hours in the discussion of what constitutes a good foreman and even a fairly brief discussion might seem out of order here. The best way to approach the subject of "The Development of Foremen" and the methods which I personally believe should be followed in any large industrial concern probably is to give in some detail an outline of the foremen's development course which was conducted during six months of last fall and winter at the plants of the International Harvester Co.

If you were to ask any of the officials of the Harvester company what they believed to be the basis of the success of our last training course, they surely would say "The principle of letting the foremen run the course themselves." The company did not run the course, neither did it plan the course or say what kind of instruction was to be given. They did cooperate to the fullest extent, however, and to my knowledge not a single request of the foremen's committee was turned down.

The story of the foremen's development course in the Harvester company is really a study of the development of a desire in the minds of many of the foremen for instruction along certain lines. I do not believe that this desire was created by the management, but rather originated with the foremen themselves through a long period of individual consideration.

Early in 1919 we received letters from foremen and assistant foremen, in which they suggested that some form of training or education for foremen was most desirable. These letters were really written without any constructive program in view, but they suggested the need and indicated a fine spirit

of loyalty to the company and further showed a genuine desire for instruction which would make them of more service to the company.

Arranges for Mass Meeting

About this time there was evidenced a desire to hold a general mass meeting of all the foremen in all the plants in Chicago. We have eight plants in Chicago, employing in the neighborhood of 1000 foremen, assistant foremen and gang bosses. This meeting was to be in the nature of a get-together meeting for the interchange of ideas and good fellowship.

Welcoming these ideas, the company's officials asked the superintendent in each of the Chicago plants to choose one foreman who they thought would be representative of the entire group at that particular plant, to be a member of the foremen's committee which would meet in the general offices of the company and plan for a mass meeting of foremen, to be held where and when this committee might choose. This committee met in the downtown office several times during the next 60 days. In its general discussion the question came up of securing for the foremen an opportunity for development and the committee decided that this should be considered at the mass meeting of foremen, and presented to the management for approval. The committee then prepared a petition which was O.K.'d by all the foremen in the Chicago plants, for a course of instruction for foremen, the character of which was to be decided at a later date. The management indicated its willingness to co-operate; instead of going ahead as it might have done by preparing a course and presenting it to the foremen, it passed the general problem back to the committee, saying that it would prefer that the foremen themselves tell the management just what they wanted in the way of a foremen's development course, and that insofar as it was possible, the company would help them out.

The committee which had been chosen by the superintendents acted temporarily and held several meetings in making up a tentative program for the course. It realized, however, that it was really not a representative group since it had been picked by the management, and the suggestion came up that an

election should be held at each of the plants and the foremen choose their representatives by secret ballot. This was done. In every factory in Chicago a secret ballot was taken, one committeeman being elected for every 25 foremen in that factory (including assistant foremen and gang bosses). Each factory committee elected a chairman and these eight chairmen from the eight shops formed a new and representative committee, which was known as the general foremen's committee, and which would formulate plans for the course.

Appoint Secretaries for Committee.

It was discovered at once that there would be a great deal of secretarial work connected with the enterprise and that few of these eight members had much time to give to the work, so they requested the management to appoint a local secretary at each plant, who could be spared from his regular work at least part of his time to assist them. The management readily agreed and the secretaries were chosen by the local superintendents. In all but one or two cases these secretaries came from the foremen's group. The committee of eight voted to make these secretaries regular voting members of the committee, stating that their reason for so doing was that the secretaries were actively employed in working out the plan and, consequently, were better informed at times than the regularly elected members. This, then, made a representative committee of 16, known as the general foremen's committee.

The management appointed a member of the industrial relations department to represent it before this committee with the title of secretary to the general foremen's committee of the foremen's development course. The secretary was not given a vote in the committee, but was to act simply as an advisor, and inform the committee at any time just what the management was able or not able to do for the foremen's development group, also to present requests from the committee to the management.

Committee Met Monthly

In the plans worked out by the committee of 16, it was arranged that the committee should meet once each month in the general offices of the company with the general secretary

acting as chairman of the meeting. When the plan was completed, it was taken to the respective plants and presented to each entire group of foremen in these factories. Some minor changes were suggested by the various groups, and as many of these suggestions as seemed practicable were put into the general plan. This plan, with a general program of the course, was then distributed to all foremen.

Up to this time the plans had been only for the Chicago plants, but some of the foremen at the Milwaukee plant who had had their ears to the ground got in touch with the movement, and expressed their desire to join in. The same plan was then presented to the Milwaukee group of foremen and accepted as offered.

The writer believes that the general subject list covered in the course, since it was suggested by this committee of foremen, is of sufficient interest to be presented here in full.

(A) Economics of Business

1. History of the International Harvester Co.
2. Products of the company.
3. Organization of the company.
4. Economics of Harvester business.
5. The world today.

(B) Shop Practice

1. Department records.
2. Setting piece work rates.
3. Reduction of costs through the elimination of spoiled work.
4. Maximum production.
5. How to meet manufacturing programs.
6. The planning department.
7. Manufacturing costs.
8. Scientific management in the factory.
9. Electricity in the shop.
10. Metallurgy.
11. Shop machine and material control.

(C) Industrial Relations

1. The right man on the right job.
   (a) Job specification and job analysis.
2. Safety, accident prevention and health.
3. History of labor unions and their aims.
4. Wage systems.
5. The development of sound industrial relations.
6. Leadership, and the application of the council plan.
7. The industrial relations department and production.

(*D*) *Popular Subjects*

1. Travelogue.
2. The history of a ball of twine.
3. To be arranged.

(*E*) *Summary of the Course*

1. To be given at the banquet at the close of the course.

Not all of these subjects were actually given in the course. The committee decided to omit the following:

1. Electricity in the shop.
2. Metallurgy
3. Safety, accident prevention and health.
4. Wage systems.

In their place other subjects were chosen which the committee believed would be of more value to the whole group.

Membership and Attendance Optional

The general plan of the course was as follows: Foremen, assistant foremen and gang bosses were eligible for membership in the classes; neither membership nor attendance was compulsory, but a record of attendance was kept. The method of presenting the subjects was to have a carefully prepared lecture about three-quarters of an hour in length, followed by an open discussion, in which any question in the minds of the foremen could be presented to the speaker.

The size of the classes varied, the smallest having about 30 men, and the largest over 200 men. All the foremen in the smaller plants met in one group while in our larger factories it was necessary to divide the group into two sections. At the McCormick works, for instance, there were two classes of 200 men each.

An outline of each talk was published and given out two weeks in advance of the lecture. This gave the men an opportunity to do some reading on the subject and prepare questions beforehand. In some cases, especially at the beginning of the course, the local plant secretary requested three or four foremen to prepare discussions. This was necessary at first in order to overcome a certain amount of diffidence on the part of

the men. In later meetings we had no trouble of this kind and it was not necessary to prepare discussions ahead of time.

Meetings Held on Company Time

As a usual thing, the local plant secretary presided at the meetings. He could, however, if he thought best, appoint some other person for that duty. The meetings were held on company time in most cases. We had one or two instances, however, where the local foremen's committee voted to hold the meetings on their own time, and it is interesting to note that when these lectures were given the attendance was as good or better than when on company time. It is thought that some of the foremen felt that their work could not safely be left during regular working hours.

One lecture was given to each class each week until the course was completed, except for a two weeks' vacation during the "flu" epidemic. Enrollment at the close of the course was practically 100 per cent of all eligible. Attendance was good in all the classes and to give some idea of just how good, the writer has taken the liberty of listing the plants taking the course with the average per cent attending the classes:

	Per cent		Per cent
McCormick works	90	Milwaukee works	85
Wisconsin steel works.....	90	Tractor works	70
McCormick twine mill.....	75	Deering twine mill.....	98
West Pullman works.....	75	Weber works.....	82

The enrollment grew from 900 to 1100. Approximately 33 1/3 per cent of the whole number of foremen took part in discussion. In some of the smaller plants this percentage ran as high as 85 per cent.

There was no examination at the close of the course, but a general get-together session was held at the Hotel LaSalle to which all members of the foremen's development course and all the management of the company were invited. Over 1100 men were present. An afternoon and evening session was held. In the afternoon General Manager and Vice President Alex Legge spoke on the Harvester organization, and Harry A. Wheeler, vice president of the Union Trust Co., spoke on the present industrial situation. This was followed by a business

meeting and a report by the general secretary. There was then a banquet and an evening session with more speakers. Harold McCormick, president of the Harvester company, acted as toastmaster at the evening session. The entire body of foremen united in a request that the foremen's development course be repeated next year, and the management signified its willingness to go ahead.

Selecting Speakers for the Course

Once the general plan was formulated, the foremen's committee was called upon to select men to present the various subjects. Really, the task of presenting one of these subjects was no light matter when it is realized that there were eight factories and in five of these groups a sufficient number of foremen to require breaking them up into two classes. This meant that any lecturer chosen by the committee must be prepared to deliver his talk 13 times. It meant, too, that the speaker should remain to listen and enter into a discussion which lasted anywhere from 15 minutes to three hours, depending on the interest of the men in the class.

The first man that the committee approached was Cyrus McCormick Jr., who was asked to prepare one of the lectures. The writer is pleased to say that he didn't hesitate one moment, but answered, "Yes, I'll do it." He looked upon it as a real privilege. It developed that the men selected by the foremen's committee were in almost every case high officials of the International Harvester Co.—only a very few were selected from outside the ranks of the organization—and I believe the officials appreciated this, since it gave them an opportunity to sell themselves and their ideals to the foremen as they had never had before.

We kept *verbatim* minutes of all the discussions, which was no small task. It kept three stenographers busy for many weeks, but we feel that it was a profitable investment, for we now have a great mass of material stowed away for future reference.

Plant Executives Address Foremen

It may seem strange that the men representing the general foremen's committee, having absolute freedom of choice

should have turned to the management for so large a number of lectures. But was this so, after all? It was to be an efficiency course in one sense, or a course that was to help every foreman fit himself for his job. That job was within the walls of our plants; in other words, he was to be an executive in that plant. And, who could better aid him in this than the men who had climbed that same ladder? And the men of the management have climbed it.

Harold F. McCormick, president, has actually spent time in the shops, assembling binders and mowers; he then went into the sales department and became a blockman and then a branch manager, and then came into the general office as treasurer, then vice president and finally president. Alex Legge, vice president and general manager, started in the Harvester company in the sales department and as a collector. Mr. Perkins, vice president in charge of manufacturing, started as a clerk in the foundry, and Mr. Utley, vice president in charge of raw materials, also began in the shops. Mr. McKinstry, in charge of sales, was a shop man. He became superintendent of the Hamilton works, then division manager, and now is a vice president. Mr. Ranney, now secretary and treasurer, began as assistant cashier.

The writer could go on through the entire list, including superintendents and works managers and other men of the management, and it is practically the story in every case that these men have come up through the ranks. The foremen are wise enough to know that they could benefit from the experience of these higher officials, who were at one time or another in positions very similar to their own.

Woman's Address is Well Received

One of the lectures of this course was given by a foreman, and three were given by outside persons, one of them a woman. Some of us had doubts about this woman's part in the work, because she had a theme that must be handled deftly. She was an elderly woman who had had a world of experience. She put her lecture across so well that one of our factory superintendents, who had been among the skeptics in regard to her subject, told her at the end of the lecture that any time

she wished to deliver that lecture to all his men, he would blow the whistle, shut down the works, and assemble the men for that purpose.

In addition to the regular classroom work of the course, the committee suggested, in order that the foremen in one plant might have the privilege of studying the work of foremen in another plant in departments similar to their own, that a special visiting schedule be arranged whereby all the foremen in Chicago works would have the privilege of visiting the other plants. It was thought by this committee that many of these foremen had worked out special methods in their departments which would be of advantage to other plants. Accordingly, such a plan was worked out, and among other things it was required that the person making the visit should write a complete report of his findings, criticising the methods in his own and the plant he visited, also making any suggestions, if he could, for better ways of doing work in his own and the other plant.

I really believe this visiting program was the most successful part of the whole foremen's development course. In visiting the different plants and in talking with the foremen in their own departments, they always had a good word to say for the privilege of visiting the other foremen in the different plants. All of the reports which these foremen made out were sent to the general secretary of the foremen's development course, where they were duplicated and copies sent to the officials of the company interested in the particular points mentioned in the report. The visiting program worked out far beyond any success that we had dared hope to achieve.

Library System Started

Soon after the course was started we found that there was a desire on the part of the foremen for references on the various subjects which were presented to them. Accordingly, a library system was started with a main library located at the general offices of the company, acting as a general clearing house for books. The books were carefully chosen with reference to the foremen's course and the foremen were supplied with a fortnightly review of all books and periodicals which had any bearing upon their work. They could obtain any of these

books or periodicals by simply sending in a small card indicating the one desired.

Besides the central library there is a small branch library in each plant, which is under the direct supervision of the local plant secretary. In two cases the local branch has become so large that it has warranted hiring a local librarian to take care of the work. In such cases a branch of the Chicago public library has been added.

That in brief is how the course was run, or rather is an explanation of how the foremen ran their own course—and it is considered a real success. Naturally when one speaks of success he wants to know results and when he tries to name results reaped from such a plan or program as this foremen's course, it is a hard thing to do, because many of the best results cannot be figured in dollars and cents. We are quite willing to leave the results to the men. They are happy about it, and if they feel that they have been benefited and helped a little bit in their work, then certainly we are well content, because it has been their course and not ours.

Introducing the New Man to His Job

I would like at this point to give just one instance of how the foremen accepted and immediately took action upon a suggestion made by one of the speakers. A. H. Young, manager of industrial relations for the International Harvester Co., was making his series of talks before the foremen on the subject "The Right Man on the Right Job." Among other things, Mr. Young laid particular stress on the proper introduction of the new employe, suggesting that the employment manager should be responsible for the original introduction, pointing out to the new man a safe path of travel from the gate of the shop to the particular department in which he was to work, showing him the best gate to use in entering the plant, pointing out the store room, lunch room, locker and toilet rooms, and commissary department, and giving him instruction on the special hazards of employment in the company, advising him of safety practices which he should keep in mind. He was then to
the new employe to the foreman and introduce him by
It then became the duty of the foreman to introduce

employe to the employe representative of that department and to two or three or more of his fellow workmen, introducing him in every case by name.

After Mr. Young had finished his talk before the foremen at the West Pullman works, one of the men during the period of discussion made a statement something as follows:

"There isn't a foreman or assistant foreman in this room but what, if he would consider this a personal matter and see if he could not make the application—just try it out, give it a fair, unbiassed trial and see what he can do—would find it a good thing. * * * Just quietly devote a few minutes to the next man who comes into our department; if we would try that out, I am sure we would be surprised at the effect it will have. And if we would follow that up to its logical conclusion, every man that we get in our departments will be a satisfied man and an efficient man, and that will reduce our labor turnover, our labor troubles and our disputes, to a great extent. * * * We don't know how much good we could get out of this by making a personal application. We come up here and listen to the lecture; it sounds good; we enjoy it. We go downstairs and say, 'That was a pretty good lecture, wasn't it?' We go home and then we forget all about it. We will hit the job just the same old way tomorrow."

Demands Trial of Plan

That got the boys started. There was some more talk along the same line after which Mr. Harrison, the superintendent, took the floor. He proposed to put the thing into practice at once. He said:

"We have something here that is material. I get a daily report from the employment manager of whom he hires. Next week I am going to ask the employment manager to give me his employment sheet, and on that will be indicated the number of men hired. Some departments will have none, and some will have quite a number, and I am going to ask each of the foremen who hired any men to get up on the floor and relate his experience—what the man did, how he acted, what he said when the foreman took him back and introduced him to at least three men. I want you to tell whether he laughed and thought you were crazy, or whether he looked serious and seemed to appreciate it. The employment manager is to take care of his part. He is to show the man the store room, the time department, the doctor's office, etc., and he is to tell him about pay day; after that it is up to you."

They *did* try it out and *did* succeed—so well, in fact, that some of the other plants adopted the method immediately. This is only one of the definite results. There are many others that might be mentioned, and there are a large number of which I know nothing.

Weekly News Letter Circulated

We found after the course had been in operation for some time that there was need of some method of follow-up. To do this we made use of a weekly news letter edited by the general secretary of the course. This news letter made a summary of the discussions at the various plants on any particular subject, making it possible for foremen in one plant to know what the discussions had been in the other plants, and in this way all were benefited. The news letters, as well as the outlines for the lectures, were all printed and a copy sent to every member of the course.

It is interesting to note at this point what one of the foremen thought the purpose of the course was. He expressed it so well that the statement is repeated in full. "The purpose of this course," he said, "is to make it possible for the foremen to share in the management and the great responsibility of this company, thus improving the company's administration, and to secure greater co-operation with his fellow workers, and in addition to help solve some of the particular problems which arise in his work, and to increase the quality and quantity of the production of every man in the shop by securing better co-operation between the foreman and his workmen."

This, in my opinion, is the thought of every member of the foremen's committee.

Almost every day we are receiving calls from the foremen asking about the plans for this coming year and when the committees will begin to meet again. The fact is that committees are already holding meetings in their local plants, and some good suggestions have been made for the course to be given this year.

Will Conduct Second Course

The plans for this year's course are not complete enough to be discussed in detail, but it seems that there is a desire

on the part of the men for a course somewhat similar to the one given last year, only that we should cover more specific subjects and not have so many general subjects discussed as last year.

There is no question in my mind but that the foremen's development course has been a success and that it has really paid in dollars and cents as well as in many other ways which cannot be figured in terms of money.

I should recommend to those contemplating a training course for foremen that they invite the foremen in to get their reactions and, better than that, that they ask the foremen to take charge of the course and run it themselves. They can do it. At least it has been so proven to our satisfaction.

The Foreman's Relationship to the Worker

By CHARLES PROSSER, Minneapolis

This is open season for the foreman. Anybody can hunt him verbally, any time, anywhere, without a license. Blaming the foreman has become one of our most popular indoor sports. Indeed, the number of people who indulge in this pleasant pastime is almost as great as the number of company officials who play golf on Saturday afternoon.

This criticism of the foreman has culminated in the charge, often made, and never refuted in public print so far as I know, that his deeds, of omission and commission, lie at the bottom of most of the unrest and disturbance in the modern industrial world. There never was a more untrue thing uttered. These criticisms against the foreman have been destructive rather than constructive, because they have been, to a very great extent, unthinking criticisms. In moments of exasperation company officials have found fault with this, that or the other subordinate or boss and the thing has been taken up and repeated from hand to hand until with the loose thinking, characteristic of American life we have taken the faults of the individual foreman and made them by a sweeping generalization true of the class. When the spotlight has been turned on the shortcomings of the foreman his critics at the same time have failed to take within the purview of their vision the changed and changing conditions, the widely sweeping, widely varying conditions to which he must adapt himself in the modern industrial world, the difficulties and the dilemmas which he must face, and the very vital and critical, almost crucial, importance of his duties—duties performed under circumstances that might well challenge the patience, the faith, the ability and the courage of any man. Not only this, but it is also true that oftentimes these criticisms and fault findings come from people who, if they faced what the foreman has been facing in the last decade, would probably not have done as well as he has done, under all the given circumstances.

production than you could turn back Niagara. We are to have more centralized and more division of labor and more of the specialized machine and more of enlarged production, but it is true that there never came into this world an exceptionally good thing that there did not follow in its wake certain evils which it took time to eradicate. We struck the shackles from the slaves, and we have worked for over 50 years with the negro as a citizen, and we haven't yet solved the problem. I likewise believe there has come with the modern production game certain evils, some of which have fallen on the shoulders of the foreman that we need to clearly recognize, because, in my opinion, they are great evils from the standpoint of effective and successful human relations with the wage worker in the plant.

Was a Dual Purpose Man

In the ancient days, at least, the foreman was a dual purpose man. On the production side of the game he represented the company in the sense that he was the aid in whose hands there was entrusted machinery and power and workmen and money in order to turn out a product. There he stood between the employer and the finished article. With that I am not concerned. On the human relations side of the game, at least in the olden times, he stood for the company; with the men, he was the company; he was its spirit; its policy, its justice, in fact, to the men he was in every sense of the word the company. But in later days, at least in his dual capacity on the other side, he represented the man. He came out of their ranks; he lived with them; they were his social world; they told him their troubles; to him they made their complaints; he sympathized with them, he hired them and he fired them, and adjusted their wage. There were times when the old-time foreman made bold to stand with his fist erect in the presence of the master of the concern and tell him that his policy in dealing with the workers was unjust. That was the halcyon day in industry when the foreman occupying that position said to the gang, "Come on, boys," and in spite of the question of the weekly wage, over-production and the

extra stunt, they followed him—because he was their personal leader. That is almost swept out of existence.

I think we can take a page from our agricultural friends. Everywhere in agriculture today they are seeking to develop what they call "dual purpose fowls and animals". That is to say, here is a fowl that is fairly good for meat purposes and fairly good for egg purposes, and in their ambition to make the things more productive, they try to develop 100 per cent meat animal without at the same time losing capacity for laying eggs. Or, pressed with the further ambition of getting 100 per cent meat animal and 100 per cent egg bearing animal —and is does not work.

In the field of animals, take the cow. The effort has been to breed a kind of super-cow which on the one hand will be superb for meat purposes and on the other hand equally superb for milk purposes, and every time they have dealt with the question they come to realize that when they stress one of those so as to try to get 100 per cent they must sacrifice the other.

Now whenever you take this man who was 50 per cent company man and 50 per cent workers' man and hedge him about with rules and regulations and policies and interferences of all kinds that tend to make him 100 per cent company man, there is only one way to do it and that is at the expense of his ancient service as workers' man, and that is just exactly what has occurred. Two sweeping circumstances have been playing around the foreman and have put him in a critical situation and surrounded him with discouragements almost enough to break his heart. On the one side all this movement in large scale production has tended to make the man an impersonal, 100 per cent company man. At a time when unrest and disturbance and the spirit among the workers has demanded that he be closer to the workers than in any preceding age, and when the drift toward 100 per cent company man has lost him his ancient place as workers' man, that is what has happened.

Think of the situation for a moment. The foreman himself has become almost an impersonality instead of a pers

ality in the large modern plant. The door of the gen manager's office is closed against him because he must do b ness through this staff which surrounds him at every t In the large modern plant inspectors and staff members all kinds, supervisors, from time study men to inspectors finished material, stand above him. Blue prints and specif tions guide his path, and the ancient prerogative in which took so much pride, of selecting and firing and handling living with his own workers has often been taken away f him by employment departments, the best of whom have t to recognize his assets and conserve them and the worst most foolish of whom have made a rubber stamp out of in his ancient prerogative—that of master and leader friend to the men in the shop.

Foreman As Brass Tag

The old personal relationship which he had with the is gone. Sometimes the foreman is one of so many they are as brass tags on the records of the company, too often the workers in his shop have expanded until he longer has a happy family, but a lot of men whom to become brass tags, in their first analogy.

The duties and the difficulties of the game of product have crowded upon his head until he no longer has time know the men in the shop and cultivate and perpetuate ancient relation of friendship with them. Not only is that t but it also is true that the initiative that he had in the ol days has been very largely taken away from him thro the centralized control, although it ought to be said in jus to scientific management that, at its best, it still gives the fo man a chance to use, if he had it, a great amount of techn knowledge in working out in practical ways the proble which the blue print and the specifications have thought at the office. It is also true that the employer has had a g deal to do with making this relationship of the foreman tow him and toward the man in the plant very impersonal. H has he done it? Apparently in many cases he has pinned

faith absolutely to scientific management—to the inventor and the machine—and when production gets short he wants another machine and another device. He will realize, if he hasn't already realized it that when you have done that thing to the limit—and it is a good thing, rightly used—you come to the point where you can't get any further excepting as you can move the spirit within the men, win their loyalty, and create the earnest service of the wage worker in a democracy. When unrest and disturbance have arisen the employer has tried to buy in, sometimes, the loyalty of the shop by setting up all sorts of welfare work back of the foreman, seeking to win over the foreman's head the good will of the worker, but it can't be bought that way. When the employer has had difficulty in handling the men in the shop he has established an employment management department, which, at its best, has co-operated with the foreman, put itself behind him, and exalted his place as leader in the shop, and at its worst has done the other very foolish thing.

Distrusts Foreman

As the struggle between capital and labor has grown more bitter in the shop the employer has come to not trust his own foreman. He is afraid he will become contaminated by reading the literature on modern industrial relations. He is jealous of intimacy between him and the men, and, in many cases, he would very much prefer that he would isolate himself from the whole group with whom the foreman's life has been spent, making the foreman's position an impersonal one, and breaking down that old personal contact which to my mind in simpler days, at least, was one of the richest assets any employer ever had beneath the roof of his shop.

While this has been going on unrest and disturbance have been given the opportunity for the radical to create strife and dissension, and the workman brings to the shop suspicion and bitterness such as he never had in the ancient days. He knows that to the company he is a brass tag and as the company has disappeared over the horizon he

comes to realize more and more deeply the detachment between him and the foreman. He sees that the foreman has come to be a 100 per cent company man, and he no longer goes to him with his troubles.

In the ancient days the men working at one task had the chance to share in the creative spirit, and they worked at the thing partly for wage, but they also worked at the thing partly for achievement, and under the leadership of the foreman they worked with it partly for victory, because they were for Bill, and they wanted Bill to put the job over.

Those things have gone out almost entirely in the shop, as I see it today. I want you to stop and think for a moment about the position of the modern foreman. You know he came from the ranks of those men. Sometimes they are getting more money now than he gets, and he gradually goes back as a worker when he realizes what he is up against. He is paralyzed, sometimes, in the face of the storm-swept place where he labors. That is not all. Bill, you know, has only one social atmosphere; he doesn't play golf with the company staff; he lives among the men, and they are his life and whatever else he achieves in this world. When the time comes for him to lay down his apron and his calipers, he is able to go out of that shop with the men respecting him and trusting him and saying, "Old Bill made us do the work, but he was just with us." He is being caught between the upper and nether edges of conditions in modern industry that are placing him, maybe for all time to come.

Pressure From Without Ineffective

Do you realize that when the worker withholds himself from the best he has and production is lowered that we set up all sorts of artificial means of injecting from the outside some sort of syrup or antiseptic into the worker so we can get more out of him—paralleling jobs, time studies, piece, and bonus, profit-sharing and company stock and all the rest of it, and that with here and there conspicuous exceptions that show how well a thing needs to be managed, many of

them have yet to prove themselves to be successes, because they have been imposed from without.

The trouble is that you have not reached the spirit of the worker, or secured team play in the plant. I don't believe you ever will get it until you restore in decided form personal contact between the foreman and his men that will enable him to use leadership and influence with the crowd in the right way to get the job done.

No man works for money alone in this world. You would lay down your job tomorrow—I don't care how much you are making—if there wasn't the creative spirit in it, if you didn't take joy in putting the job over and seeing the thing accomplished. That same thing is in the men in the plant. No matter how rough and radical they may be. They listen to the voice of Bill when Bill is their natural leader. There is loyalty for leadership in man, and you will only get it out in proportion as you make it possible for the foreman to be restored to his ancient purpose as the dual purpose man of the establishment. All schemes of scientific management, necessary as they are, and all schemes of personnel management, necessary and admirable as they are, will fail if they are not founded on the solid rock of personal relations between the company and the men—not artificial relations of blue print and catalog and things of that kind—but the day-by-day contact, man to man, between the foreman on the job and the gang.

Restore Foreman to Old Position

Now if you have pinned your faith to 100 per cent company man, if you believe in the inventor and the machine as the "colossus of Rhodes", and you think they will accomplish it for you, keep on going just the way you are. The law of diminishing returns will work with you, if it already hasn't done it, and trouble is your heritage. But if you believe that you are dealing with human beings and American workers and that while all these other things are excellent, they will fail excepting as they are coupled up with the restoration of the ancient position of the foreman as leader of his men.

Be certain that the foreman has enough help so that he can have time to cultivate his men and can come to know them, and that they can come to know and respect and follow him. When you hire men at the gate of the factory, let them be hired subject to the foreman's approval. When he says he doesn't want them any more, and he sticks with it, after you have tried to persuade him, you would better let them go. When you cannot trust him any longer, get another foreman.

You want to be back of him, because he is *YOU,* and when the whole story is written, if they can say on Bill's tombstone, "Here is Bill, he was a D——n good foreman; he made us do the work, but we followed him because we respected him, and sometimes loved him," you may rest assured that back of that figure of Bill those men have in mind is the company that employed him, for to them he is the company, and I don't know that I can do any better, in closing, than to paraphrase one of Kipling's statements

Here's to the American foreman!
As good as we are, and as bad
as he is,
He's as good as we are; as bad as we are!

Employment Problems

By Ralph G. Wells, Boston.

Problems of finance, of sales, of methods and processes seem simple today when compared with that of labor relations. Yet it has not been many years since the former were given far more thought and attention by business executives than the latter. Perhaps it was the neglect of this phase of management in the past that has permitted the situation to reach its present acute stage.

It is unnecessary today to emphasize the importance of this subject. There is no escaping that at this time it is the largest and most critical problem in industry. Solutions must be reached if industry is to continue its progress.

Perhaps the most hopeful sign is that our ablest men are keenly alive to the situation, concentrating their attention on it, bending every effort to find the best method of securing and maintaining harmonious relations with the working force. Labor leaders and sociologists still may cling to their prejudices and be sceptical as to the truth of this statement, but, nevertheless, it is true that the majority of business men are sincerely and earnestly striving to find a just and equitable solution.

Foundrymen are seeking, not only for those things which will improve the general situation, but also for concrete suggestions of practical application. There is no dearth of suggestions. In fact, there is an overabundance. The wide spread and thorough discussion of industrial relations during recent years has brought forth an avalanche of ideas, plans and schemes. Some have value; some have none. Many are mere make-shifts.

It is the purpose of this paper to suggest a method whereby you may determine what is the situation on your own plant; just what are your needs, and from this knowledge decide what steps you should take.

Now, if this were a problem of power or sales, or of finance, you naturally would proceed first to make a careful survey, analyzing every important phase of the situation from which you could draw up an accurate estimate of your needs. Is it not advisable to adopt a similar method of procedure with regard to industrial relations?

Analysis is Paramount

A problem well analyzed is half solved. Nothing helps so much as accurate and adequate knowledge of conditions. In fact, the difficulties frequently are disclosed so clearly that they seem almost to solve themselves. Bad conditions and unsuspected faults that have grown up unnoticed are laid bare.

Some may claim that human relations are too intangible, too intricate and too complex to permit such a cold-blooded approach as an analysis would seem to imply. This viewpoint has done much harm. There has been entirely too much emotion and too much inspirational vagary on the part of well-meaning philanthropists and humanitarians. They, and the self-centered paternalists, have done much to befog the issue and disgust the hard-headed wage-earner, who desires merely the thing to which he feels that he is justly entitled. He has no use for largess nor uplift activities doled out as charity. It is no wonder that the name *welfare work* is odious to the worker.

Our aim is not that of social service workers or of philanthropists. We are concerned alone with the questions of relations between practical men whose work necessitates constant contact under conditions frequently most trying.

Complex Factors Enter

Truly, the problem is complex and intangible, because it is made up of so many variable factors. Each industry and, in fact, each individual plant in each industry, is a problem in itself. Hours, wages, products, distance from labor centers, competition with other employers, class of employes needed and available, special requirements as to skill, training, education, physical and mental qualities, and numerous other items, are quite different in each plant. The personnel of the supervising

force, and executive staff, the labor traditions and precedents, public opinion and other more or less intangible factors, must influence your procedure and determine your action. These, as well as the other conditions, vary not only between plants and industries, but even vary from time to time in any given plant. The situation changes from year to year. The solution of to-day, no matter how perfect for the time being, cannot serve for all times. Moreover, solutions satisfactory at this time would have been given slight consideration a short time ago.

The very presence of so many variables in the equation and because it is so complex and intricate, make it essential to split this problem up into its component parts. A careful survey is the best possible way of doing this.

Other objections can and will be raised to such an approach as is proposed here. Some are made on the grounds that it is unnecessary, impractical and too complicated. Argument in such case is almost futile. Actual demonstration of the real work is the only adequate answer.

The method suggested is not nearly so complicated or elaborate as it appears. It merely is a methodical way of getting at facts which are necessary to a proper understanding of the problem. It endeavors by systematic arrangement of parts to avoid the danger of overlooking details seemingly unimportant but in reality of great moment. Sand in the bearings of a machine does not look big, but it causes a lot of friction.

Problem One of Management

Industrial relations is a management problem. It is not a separate function nor a question of welfare work, social service, moral uplift nor philanthropy; neither is it an academic profession, nor yet an occult mystery known to a chosen few. It simply is one phase of management, and while differing distinctly from the more material phases, it must not be separated from them.

The handling of employes and all relations with them is not only a function of management, but an unavoidable responsibility. Every person connected with the management force,

be he president, foreman or clerk, must recognize this responsibility, and school himself to carry out his part of this duty adequately, in full harmony with the policies of his company. To create a new department which will in any way lessen the sense of individual responsibility of the executive staff or supervisory force is a fatal mistake. If an industrial relations department is needed, have it clearly understood that its job is to advise and assist; but not in any way to relieve anyone of his responsibility. Such a department may be of material assistance and can stimulate interest, direct attention, or, if necessary, act as a check; but it should operate as a staff rather than as a line department.

Labor troubles, except those due to outside agitation and jurisdictional disputes within labor unions frequently are due to faulty management. Even in these cases their severity is increased or decreased in proportion to the extent of good or bad management. Well managed plants are far less susceptible to contagious labor troubles than those not so well administered. Good management is an antidote and preventative of labor difficulties. As it definitely promotes good industrial relations, a comprehensive survey should be made to determine whether the administrative practices are what they should be. This means a careful analysis of all management activities affecting the employe, not only to determine whether the policies are sound, but also whether the methods and their execution are in accord with the policy of the company.

No Cure-All Available

There is no substitute for good management so far as labor relations are concerned. Neither is there any one solution or panacea for the difficulties encountered. Rather does the solution lie in three essential steps:

1. The establishment of sound policies as a basis for action.
2. The accurate translation of these policies into actual practice.
3. The proper supervision of the individual practices, to make sure that they adequately represent the spirit of the accepted policies.

However, all three of these steps are not sufficient unless all details are taken into consideration and made to correspond to the policies. Even seemingly unimportant details, small in themselves, in the aggregate may have a surprising influence on labor relations. It is precisely because every detail of administration affecting the worker must be studied that a survey is desirable.

However, do not imagine that making a labor audit means paying attention to concrete details only. It is quite as important to consider the general labor policies of the company, the spirit of the executives in carrying out these policies, the attitude of the workers toward the management; as well as community conditions, sources of labor supply, and other matters outside of the plant. At the outset, a fairly complete list of points to be covered should be worked out. This commonly is known as a checklist. An example of such a list is given at the close of this paper, merely as a suggestion of the points to be covered. Using it as a basis, work out an individual analysis, covering the points most essential to an accurate knowledge of your particular employe relations.

Don't Delegate All Interest

You may decide to make this survey yourself or you may find it advisable to bring in a firm of competent engineers of recognized standing. In either event, probably the best method of starting the work is to lay the matter before your staff, or else to appoint a special committee composed of the chief production executives, and after interesting them in the subject request them to prepare for you a report of standard practices covering every aspect of your labor problem and your relations with employes. The mere compiling of a report of standard practices in itself will be a most helpful education for your organization; it will also develop enough problems from day to day to keep you busy for some time.

Then, in addition to the preparation of your standard practice, you, or whoever else is making the survey, in consultation with this same committee can make a study of all other points to be covered and not touched on sufficiently in the re-

port. Of course, it is possible for an individual to make such a survey in two or three weeks or a month, and such a survey will be well worth while, but the method of doing it through a special committee or your staff is far superior, although it will take more time. One great advantage of the latter method is that the members of your committee, in discussing their findings and their recommendations, have automatically *sold* the idea to themselves. Then when approval is given for carrying out the recommendations, you are to have immediate co-operation, instead of opposition or half-hearted support.

Correct Faults as Discovered

Do not wait until the survey is complete to correct faults discovered; there will be enough left to do after the report is finished, so that it is well to get much of the work started while the survey is in progress. Unless yours be the exceptional plant, you will be surprised how policies and practices either are not uniform throughout the various departments or have become distorted through carelessness and mis-use. The submission of a report which contains a formidable list of recommendations constitutes a distinct advantage. The mere sight of it is so discouraging that action on it is postponed until some more favorable opportunity, which seldom arrives.

In analyzing your labor problem, each point in your list should be studied to determine the existing practice, whether that practice is uniform in all departments, and what results are obtained. With these data, supported by such statistics as are available, the particular phase covered is examined from various angles to see whether it has any flaws; whether it is adequate and is producing satisfactory results. Comparison should be made with the experiences and practices of other firms in handling the same situation, to see whether their method is better than yours. During the study, the specific purpose for which each activity was created should be kept in mind, and its actual effect upon employes compared with the desired effect.

The principal phases will have to be examined more or less in detail. As an illustration: Suppose "Introduction to the job" is being considered. This immediately raises the question as to how the new employe is introduced into the plant and to his job. Does the method used create the right impression; is he made to feel at home and given such information and instruction regarding the company, plant conveniences, rules and regulations, and about the work which he is to do, as will enable him to be assimilated by the organization and fit into his particular work in as short a time and with a minimum of disturbance to the routine of the organization? Is he given a clear understanding as to wage rates, working conditions, his duties, and the other terms of employment? Is he given a book of rules and plant information or made familiar with these things by some other method? Do the steps by which he is brought into contact with his foreman encourage the right feeling and attitude toward the foreman? What information is given regarding special features, such as insurance plant, mutual benefit association, bonuses, etc? How does he learn about lockers, toilet facilities, lunch rooms, transportation arrangements and other plant conveniences? What steps are taken to discourage hazing by older employes?

Perhaps the most important question under this item is that of immediate instruction. Is there a definite method by which the new employe is given such necessary and adequate instruction before he takes up his work, or is he allowed to pick this up in a more or less haphazard fashion, depending on whether the foreman or some more experienced employe has the time and inclination to tell him what to do?

Detail is Essential

The foregoing will give a general idea of the way in which the items of a survey are handled. It may seem like an unnecessarily detailed analysis, but the purpose of the labor survey is to make you and your associates thoroughly familiar with every angle of the labor conditions in your plant, and of your methods, practices and policies. When you have such informa-

tion gathered together, either in the form of a written report or accumulated in your own mind, it is fairly evident that the weak spots in your program will stand out and that you will be able to determine at least those things which should be corrected. From this it will be comparatively easy to work out such additional features of your labor relations program as are needed.

While the labor problem of each plant is different from that of every other plant, yet it cannot be considered by itself alone. Our industrial and economic relations are so closely interwoven that although each organization has its individuality, yet it is affected by certain outside influences which must be taken into consideration at all times. Among these outside influences are such things as general business, social and political conditions; the high cost of living, the readjustment following the war, wide spread discontent or agitation.

As an individual it is difficult for you to do much to remedy these conditions, except as you participate and cooperate together with others in national movements and national organizations toward some common end. Nevertheless, in considering your problem it is well to determine in your own mind just how much these general conditions are affecting you, and what steps you, as an individual, can take to counteract their influences in your locality. It is also evident that if your relations with your own employes are on a sound basis, such general conditions will affect you less than if you had neglected the employment relations and were doing nothing to tie your employes to you and to win their loyalty and confidence.

What is Without the Gates?

Another outside influence of great importance is that of local conditions. This frequently is overlooked. Few manufacturers realize the extent to which their difficulties are complicated by community conditions. The housing problem, the kind of service rendered by your merchants, and the prices they charge, the adequacy of transportation facilities to and from the plant, the recreation facilities available to your employes, and whether

they can spend their time in wholesome recreation or must resort to loafing and other practices of a more harmful end, are examples of this phase. What of the family life? Are there good schools for the children, are there enough churches, are there sufficient amusement centers and theatres, what is the general social atmosphere of the community; is it a healthful one where a man may bring up his family satisfactorily? Or is it one where he must see his children steadily deteriorate in their standards? All of these factors and others contribute to the happiness or unhappiness of the employe and reflect themselves in his attitude toward you, toward his work and in his efficiency. Discontent breeds less rapidly where there is a healthy community life. Run over in your mind some of the more serious labor disturbances which have occurred in this country, and you will recall immediately that many of them were in communities where the living and social conditions were far below America's standards.

Better Outside Influences

The relation between the community and the plant cannot be escaped. Management must take an interest in the community where the plant is located and from which the labor supply is drawn. Other employers in the vicinity and their practices also enter into the situation. So long as there are one or two plants in your locality whose labor policies breed discontent, they are as much of a menace to you as a fire trap next to a theatre. For your own protection, it is urgent that you use such moral persuasion as you can on other employers near you, to induce them to bring their standards up to those which should prevail in your community.

Fortunately the situation within your own plant is more directly under your own control and obviously will occupy the major part of your attention.

In considering the situation in the individual plant, it is essential that executives keep constantly in mind the idea that the ultimate goal to be attained is that of mutual confidence, loyalty and understanding. Methods and plans are of value only as they contribute to this end. Friction, misunderstanding

and antagonism must be avoided and eliminated. There should be personal and direct contact between the working force and company officials to insure intimate knowledge and mutual understanding.

Sinister Influences Feared

Two influences have operated in the past and even today are increasing the antagonism between managers and workers.

On the one hand, the action of radical and unreasonable agitators has tended to prejudice management against labor as a whole. We may all agree in feeling this distrust so far as it concerns the agitator. Yet the average workman's intentions and aspirations differ but little from that of anyone else. He has had perhaps less educational advantages, but in the absence of friction and class antagonism responds to the same stimulus as do others.

On the other hand, industry suffers today from the blunders made in the past by the repressive, domineering type of management, which did not hesitate to disregard the rights of competitor, customer or worker, and take every possible advantage of them.

The main task today is to take such steps as will counteract completely these two influences and bring about mutual confidence, loyalty and co-operation, so that the combined force of capital, labor and management may be utilized without loss from friction in carrying on of the world's industries and commerce.

Collective bargaining has been suggested as a remedy and as a means of co-operation. It has many supporters in certain circles, but the majority of employers who have had actual experience with it apparently do not consider it to be a permanent solution. This method of promoting better relations has failed to win support.

Collective dealing, through shop committees or some form of employes' representation, although comparatively new, seems to be far more successful, as is evidenced by the testimony of such firms as the International Harvester Co., White Motor Co., Bethlehem Steel Co. and many other establishments, both

large and small. Enough success has been attained by these companies to compel careful consideration of this method.

Foreign Problems Differ

We should not attach too much importance to English methods and experiences, which have to do with a psychologically different type of workman and deal in a cut-and-dried way between upper and lower classes. American conditions are different and American workmen, on the whole, are not class-conscious. They consider themselves the equals of the management and object to attempts which place them in a different social stratum.

Class consciousness merely is accentuated and its growth fostered by organizing the management and the workers into separate groups, pitting them one against another through partial tribunals and courts of arbitration. Legalizing friction and prolonging litigation indefinitely, postpones the time when management and men may come together in co-operative understanding as two allied groups that will pool their strength and resources to gain a common goal.

Class distinction and class antagonism should be eliminated from industry as wasteful of human energy. Management, because of its stronger position, owes it to itself to take the lead in bringing about more harmonious relations. It should seek to prevent American industry from adopting foreign methods just because large numbers of foreign workmen are employed.

American methods imply constant progress and mutual adaptation to each other's needs. This means a multiplicity of little adjustments, varied from plant to plant and from time to time as occasion warrants. The solution does not seem to lie in the adoption of imposing and elaborate plans, but more in the development of simple methods for the determining of little adjustments that are needed from day to day.

Understanding Forms Foundation

It all comes back sooner or later to a question of closer contact and understanding. In the smaller organizations this can and should be done by the chief executive themselves; but

in larger organizations they have not the necessary amount of time to do this. Here is where the need for an industrial relations department is found. The responsibility for maintaining contact and seeing that the labor policies are correctly interpreted and carried out must be handled through a special department especially organized and trained for this purpose.

Whether a managing executive or a special department is to handle the problem, a labor survey such as is suggested will serve as a first step in determining what policies and methods are needed in the particular plant to bring about the desired improvement in relations between management and men.

Proceed with the installation of your plans gradually. Every organization has a rate of assimilation and too rapid progress is dangerous. If possible, install any radical changes in a tentative manner, so that you may have an opportunity to test them and see how they work before committing yourself definitely to the plan. The greatest danger to be avoided is that of disorganizing or unsettling your supervisory force as well as your working force. A slow and gradual development always is to be preferred to complete installations which necessitate sudden and radical changes. No permanent and lasting program can be worked out in advance on paper; nor can it be installed over night unless you are building an entirely new organization.

In general, each recommendation should be examined to see whether it is needed, whether the proposal meets the need adequately. Can it be done more simply? Will it create the right impression on the employe or will it antagonize him? Avoid cut and dried plans brought in from the outside. It is better to have one adapted to your own particular need.

There is one point which, because of its importance, deserves to be the subject of almost every paragraph. That is, that the spirit is far more important than the method. Some firms that apparently have most satisfactory labor conditions do not have an elaborate industrial relations program, but you will find there good management and an executive staff which has succeeded in winning the confidence and loyalty of their working force.

UMMARY OF POINTS TO BE CONSIDERED IN MAKING A LABOR SURVEY

itions of general busincss: Labor, social, economic and political ditions to situation in plant or industry where survey is being le.

mmunity conditions: as outlined in the first part of this paper.

r outside influences, such as public opinion, conditions on plants other employers in similar lines of work or in the same nity.

or history, traditions and precedents: Not only of the particu- plant and industry, but also of community where plant is located.

eral labor policies: Methods by which they are executed, and the artment in charge of such work.

sting labor conditions. Results obtained by present policies and hods.

ncial relations: Wage systems in operation, special incentives led. Wage rates, timekeeping system, methods of payment, is and advances.

visions for saving and thrift: Insurance, accident, health and pension plants, home ownership, vacations.

ticipation in profits: Profit-sharing, stock-ownership, wage-divids, bonuses for length of service, quantity and quality of protion, waste elimination, suggestions and meritorious service.

loyment relations: Sources of labor supply, methods of atting applicants, standing of plant as a good place to work, hods of interviewing, selection, placement and introduction to job, follow-up, transfer, promotion, terminations, including s, lay-offs, discharges, automatic drops, attendance both tardies absentees.

ining and instructions: Methods of training new employes, imliate instruction, shop training, vestibule school, apprenticeship em, methods of developing employes for promotion, emergency ce, training of instructors, immigrant education.

rking relations: Shop rules and regulations, hours, shifts, discipline, leadership and control, working conditions, fatigue elimiion labor saving, methods of handling grievances, production hods and schedules, flow of materials, inspection, accident vention, plant sanitation, plant conveniences, such as toilets, cers, etc., publicity on plant, relations between supervisory force working force, regularity and permanency of work, interest enthusiasm.

cial service for employes: Rest room and recreation facilities, ch counters and restaurant, medical department, physicians, ses, hospitals and clinics, health protection, employes stores and operative buying.

nployes' Activities: Special committees, employes' representa-n, athletics, social club, plant paper, mutual benefit associations,

credit unions, provisions for special assistance, advice on personal matters, legal and financial aid.

The list necessarily is much condensed and merely attempts to suggest the principal phases to be considered. In making a survey or building up a check list, numerous other items would naturally be added and all of the items would have to be elaborated to cover every angle that should be taken into consideration.

The Right Man on the Right Job

By A. H. Young, Chicago.

I should like to introduce my subject to you by a few sharp contrasts. First of all, there is a change which has come about in industry within the last two or three decades in the matter of ownership. A few years ago, most industries and plants were owned individually. Either one man or a small group of men owned a plant or a particular industry. The plants themselves in those days were what we would now consider relatively small, with possibly two or three hundred employes, and the owners knew every man by name, knew his children as well, and knew when they would be through school and could come into the shop. There was a happy, intimate, human contact.

Personal Contact Lost

We now have, as contrasted with that, ownership by stockholders. Most of our big corporations today have thousands of stockholders. These stockholders elect their boards of directors, who in turn select their staffs of managers to take charge of the business, and right there a wide gap has been brought about—a loss in personal contact.

This has been further accentuated by the growth of big business itself. The perfection of power development and transmission has made possible great manufacturing units. The perfection of means of transportation and communication has also lent itself to this, until now there are many plants that number their employes by the thousand. This has had the effect of making personal and intimate contact impossible, even between the managing representatives of the stockholder-owners and the workers.

In the old days, getting the right man on the right job was not much of an operation. We did not have employment methods then. I think one can rightly say that the matter of hiring a man was nothing more or less than crooking

your finger. If a foreman at the beginning of a turn found a machine idle because of the absence of one of the men, he simply went out to the gate, looked the bunch over, picked a likely looking applicant, and beckoned to him. The man stepped out of the line, the foreman put his proposition up to him, and if he accepted, the foreman said, "All right; come on and go to work." When the timekeeper came around he was notified that this man was at work and to put his name on the payroll.

Centralized Employment Needed

The obvious inefficiencies of that method did much to bring about eventually the formation of centralized employment departments. In the first place, the selection of a man at the gate involved the absence of the foreman from his department at the time he was laying out the day's work and was needed on the job more than at any other time. Furthermore, regardless of how efficient a foreman he might be, he occasionally made a bad guess. Sometimes, although an applicant was likely looking, it would be found after a day or two that he was a "four-flusher"—he wouldn't work. He therefore, was "fired." There was no formality about it; he was simply told to get his time from the cashier. What was the result? The man showed up with the others at the gate the next morning, looking for a job again, and another foreman was likewise impressed by his appearance, and he likewise crooked his finger, and the man was taken on again, with the same result. There are cases on record in some plants where the same man has been hired and fired 10 or 12 times, and for the same cause each time—because he wouldn't work. There was no central clearing house; no passing on of the information that the first man hiring him secured.

Contrast that method with that of today. First of all, when a man is desired for any particular job, a requisition is sent in to the employment manager. And what type of man is he? The employment manager of today is chosen, not because he has had a college education, not because he is a phrenologist or psychologist, or has any sort of mystic

and with which he can make men reveal their true selves and discover which are the workers and which are not; he is chosen chiefly because of his personality and his vision of his opportunity to serve his fellow man.

Employment Job Like a Coarse Sieve

My conception of the employment manager's job is that he is simply a coarse sieve; that he will be able, by intelligent inquiry, to sift out the manifestly unfit applicants—men with the poor records, the men who cannot intelligently answer the questions he puts to them, and the men who, by their attitude, show that they are undesirable as employes—and so send in to the foreman the best applicants he can get, the foreman to judge of the man's final fitness for the job by his actual performance and his shop attitude.

Therefore, the first requisite of an employment manager today is that he shall know in detail the duties of every job in the plant. He should not only know the idiosyncracies of the foreman in order to decide what type of man he is going to put with him to get along satisfactorily, but he should know intimately the physical and mental requirements of every job in the shop. He should have in his files a set of specifications for each job and a record of the general characteristics a man must have in order to meet these specifications, and when a requisition comes in, he instantly must be able to visualize the type of man he must get to do the work.

Applicants Undergo Physical Examination

Having selected an applicant who promises to be favorably considered by the foreman, the next operation on the part of the employment manager of the modern plant is to refer him to the doctor for a complete physical examination. The purpose of this is, not that industry proposes to rid itself of all men who are not physically perfect, but that no man shall be assigned a job that will work a physical hardship upon him. For instance, if a man has a bad hernia, or a serious heart lesion, it is manifestly unfair to put him at a job where he must do heavy lifting or where he must run up and down stairs often. If he has incipient lung trouble, or chronic throat

trouble, it would be wrong to put him at work where dust and fumes prevail. If a man has a communicable disease, he should not, of course, be put to work among other men.

Having completed the examination, the doctor, we will say, classifies the men as *A, B* or *C*.

Class *A* means that the man can take any job in the shop without fear of its working a physical hardship upon him. His condition is such he can do the work.

Class *B* means some disability which would debar him from certain occupations, and this means that the employment manager should call up the doctor, describe the proposed job, and get his O. K. before that man can go to work. Furthermore, if, after having put him to work, he is later transferred to another job, it should be the duty of the employment manager to call up the doctor again and clear with him about the new job, because it is just as important that a man be cared for after employment as before.

If he is rated in Class *C*, the man is rejected. This might be for some communicable disease, or because the man had lost the sight of one eye. It is a rule of many foundries that a man who has entirely lost the sight of one eye shall not be hired. The reason for this is two-fold, and both are fair. In the first place, it is hardly square to put a man who has all his eggs in one basket in a position which will expose him to greater hazard than he would encounter in many other lines of industry, and while it is true that a man with one eye can see almost as well as a man with two, still, if anything happens to the other eye, he is totally, permanently disabled. In the second place, under the present compensation act, if a man lost the sight of his second eye while at work, the industry employing him would have to pay for total permanent incapacity, which means either a series of monthly payments extending over life, or a large sum in total cash settlement. This is hardly a fair proposition, and for those two reasons it is best, in a hazardous line of work, to reject men thus handicapped.

"Sells" Company to New Man

The applicant having been O K'd by the doctor, it will next be the employment manager's job to "sell" the company to him,

tell him something of the history of the plant, and what promotional opportunity there is there for him. Some plants make a practice of giving new employes a motion picture show or illustrated lantern slide lecture, showing first the town, the location of the plant, the different residence districts, the names of the streets leading to the plant, the surrounding country, then a view of the plant itself, the gates, the pay stations, etc., and then, by means of photographs and diagrams, the whole process of manufacture at that plant.

The new man should then be personally escorted to his job by some one from the employment office, who on the way will point out the safe path of travel, show him the gate where he is to come in in the morning, point out the store room, lunch room, locker and toilet rooms, and other things in which he may be interested, and then turn him over to the foreman, introducing him by name. The foreman will shake hands with him and make sure of getting his name right; then he will explain his new work to him, tell him of any hazards in connection therewith, and introduce him to two or three of his follow workmen by name. In other words, that new applicant should be invited into some sort of human contact with his fellow workmen. He should be made to feel that he is recognized as a human being with a soul—not a mere cog in the machinery.

Keeps List of Substitute Jobs

The wise employment manager will also have in his files a list of substitute occupations. He will find out at the time a man is employed what his aspirations are and what he may be studying to fit himself for. Then, too, there are times when a man is hired for a certain position who is capable of something better, but there is no opening in his particular line just at that time. By maintaining such a file, the employment manager will be able, when a requisition is received for a man with those qualifications, to offer this promotional opportunity to a present employe, rather than hiring someone from the outside. This will do much to aid continuity and stability of service.

I have heard it said many times that the work of employ-

ment management consists in fitting square pegs into square holes and round pegs into round holes, making sure, if you have a square peg in a round hole, that it is changed, through some fine system of accounting, and put in a square hole. And I respectfully say that it isn't anything of the kind. In the first place, you cannot classify jobs as square and round, and you cannot classify men as square and round pegs.

Employing Like Fitting Key to Shaft

If a simile is to be used for the operation of employment management I would say it is like the process of fitting a key in the keyway to hold the pulley on properly. If you are a real craftsman, you select a bar of steel and draw the temper. If in trying to draw the temper you find the steel is unfit for that job, you lay it aside to be used for something else. Then you pick out another bar, work it down to a rough shape, then you put it in the vise, file it, and work it down until it will almost fit in that keyway. You chalk it and try it again; there is a rough spot here and you file that down; or, if you run across a flaw you put it aside and start all over again, if necessary. And when you get through, if you are a real craftsman your pulley rides on the shaft smoothly and the last little tap of your hammer locks it in position without sledging. If you sledge it into place it may hold your pulley, but you may knock a bearing out of line, or the shaft itself may be out of line, and when the time comes later that you want to make a little adjustment or take it off altogether, you have to work for two or three hours to get that key off, whereas if you had been a real craftsman in the first place, one or two slight pulls of your tool would have been sufficient.

Employment management, properly done by real craftsmen, will keep men and management performing their full functions in complete harmony and without friction, and that is the essential purpose and effect of getting the right man on the right job.

Let He Who Would Be Great Be Servant to All

I don't want to pose before you as a deeply religious man, neither am I going to apologize to you for quoting the Bible,

but recently I have heard a number of men discuss various texts in the Bible, and four employment managers, at four different times (and they had not cleared with each other at all) have expressed this thought: Whereas they used to think that the golden rule, "As ye would that others should do unto ye, do ye also unto them," was the finest text in the Bible and should be the rule and guide to all, they had recently come to believe that another text a little farther along in the book of Mark was still greater—"He among you that would be greatest, let him be the servant of all."

I respectfully say to you that the basis of sound industrial relations lies certainly within those two texts, if not within the last alone. And I say that the latter is the greater, because sometimes this proposition of doing unto the other fellow as you would have him do unto you is construed to be just a square deal, a "fifty-fifty" policy, and some of us take the attitude that we will come up to the "fifty" mark and if the other fellow comes up we will meet him half way and go along together, but if he doesn't do his part, that is no concern of ours.

But we cannot afford to take that attitude, because the other fellow may not have had the same advantages we have had. He may have been subject to radical propaganda that we do not realize at all. If we will sweep all distinctions aside and simply conceive, as the Carpenter of Nazareth did, that he among us who would be greatest should be the servant of all, we will, I believe, be able to get together on a basis which will help to make for the universal brotherhood of man.

Discussion—Industrial Relations Problems

The Chairman, C. B. CONNELLEY.—I have listened to what Mr. Young said about the psychologists, about the six weeks' course, etc. with a great deal of pleasure and merriment. I was present one time at a gathering of men who were uplifters. There was a criminal there who had been, through Billy Sunday's efforts, changed in his way of living, and was doing a real piece of work for the Y. M. C. A. He said in his discussion of this work, "I am amused to say to you people that the psychology of your employment methods is all wrong."

"My physiognomy you see is very much distorted. When I was a boy of fifteen before I became a criminal I had really nice features, but, in my life in the West, and in the East, and being in the awful brawls that I have been in, I am disfigured as you see,"—(and he was; he was one of the most homely looking men I have ever seen). He said, "A psychologist examined me and he said, 'You won't do at all. This bone here and this bone here is not all right. You are not fitted to be a blacksmith'."

"If I could only have told that young man," said the reformed criminal, "where I got those awful bumps, he would have changed his instruction in psychologies, I am sure, because I had to serve five years for the one I got up there trying to get away from a man."

It only goes to show that after all, in our work here, in placement and in employment manager capacity, that we have so much to do.

I am glad that Mr. Young brought out the point about the physical examination. We are having lots of trouble with the organized labor man in Pennsylvania, because he doesn't believe in examining an applicant. I have always believed in it; I believe in it for two reasons. In Pennsylvania we pay almost twelve million dollars a year in compensation, which is too

much money to spend in this way. On the other hand, I believe in placing the man and physical condition in the right position, in the right job, just as Mr. Young says.

A MEMBER.—I notice that Mr. Young spoke about *A*, *B*, and *C* class men in the examination. I think that is correct, and when you come to the *C* man you turned him down altogether. Now in my limited experience I have found very often that while the *C* man might not be actually a good man, yet very often he did the best he could. We have got to do something with the *C* man; perhaps he became a *C* man in the employ of the company, and we cannot kick him out on the street. If we do, he is going to join the radicals. He is here now and we can't kill him off; it is not a matter of our not wanting anything to do with him. We have to do something with him. He is there anyway.

ARTHUR H. YOUNG.—The *C* man is a problem. With us the classification for *C* men is small. For instance we do not feel that a man with a communicable disease should be put at work among his fellows. He is told exactly why he is rejected, and if he cares to reapply and can show he is free from communicable disease of any kind, he is employed. There are certain inequalities; for instance, as a rule a man who has lost the sight of a single eye is not employed by us, because under the laws of most of the states in which we operate, if he should lose his remaining eye we would have to pay for total permanent incapacity, which is a pretty stiff figure in some of the states, and until, as in one or two states,. the law is changed so we pay only for the disability he might suffer with us, we don't feel it fair to be asked to incur that additional expense. We are co-operating most sincerely with the branches of the Federal Bureau for Vocational Education and with Dr. Motts' newly formed association for extending to the industrial cripples the benefits of the establishments originally set up for caring for the returned men from overseas.

We have men in our shops whom we have employed who have lost both feet or a hand or a foot or who are without their hearing, where they are put in under special conditions of tutoring, yet, broadly speaking, our employment manager and

our doctors would not be allowed to hire that man except under a special study made by us. I don't want to seem to be put in that class of employers who simply disregard a man who is incapacitated, without reference to a special duty he might perform better than someone else, because when you make a special study for that man and give him a job, all his own, your labor turnover there is reduced substantially, he appreciates it, and you don't have to figure that the flirting of another employer for a cent or two an hour will influence him, or he will go shopping for a job, as has been so common with able-bodied men. It is all a matter of individual consideration rather than a broad, general rule.

MR. C. B. KENNERSON.—I would like to ask Mr. Young if the employment manager fulfills the same function in firing a man that he does in hiring a man. If a foreman is not satisfied with a man, is he referred to the employment manager for discharge?

MR. ARTHUR H. YOUNG.—The foreman recommends discharge, or recommends transfer, as he sees fit. If a foreman recommends discharge, all of the men leaving the service must clear through the employment manager. If the foreman recommends discharge, and, after a careful interview, the employment manager feels that the penalty was rather unjust, or because of the difficulty of recruiting labor, as has been so recently, would like to conserve that man, and the man is really penitent, and shows some promise of making good in another department, then the employment manager goes back to the foreman with the result of his interview and secures the consent of the foreman to transfer the man. If he is unable to secure the foreman's consent, and the foreman insists that he should be discharged, the next step would be that the employment manager would go to the local superintendent with him and discuss the matter, and take the ruling of the local superintendent. I don't know of that happening in but three cases in 26 plants within the last year. In two of the three cases that went to the superintendent, the foreman was upheld and the man was discharged.

MR. MEYER BLOOMFIELD.—First of all, in the use of the physically handicapped, much depends on the nature of the machinery you use. It so happens that a few days ago I looked over the records at the Ford company of their use of blind men. In that company a blind man now does the work of two men with good sight in certain operations. At the Goodyear company I watched the deaf mutes, scores of them, at work. Those men are highly competent mechanics; they are in a class by themselves, have a club room of their own, and, as Mr. Young said, the problem of turnover is completely eliminated.

Another problem is the question of physical examination. Here we run up against not only the attitude of the union, but often of the American workman, who regards it as an invasion of his rights and his privileges and privacy, and as a scheme of creating a blacklist. The reason for the opposition to the physical examination is the failure of the management to sell to the average workman the real importance, the protective value, and the scheme of justice underlying physical examination. It is not an employe's private game to examine the men; it is for the welfare of all, and I want to illustrate with one story of a personal experience in Pennsylvania.

There is a great printing establishment in which the men were absolutely opposed for years to the introduction of a surgeon and to physical examination. One day one of the most obstinate objectors to physical examination was working on a roller in one of the big rotary presses and an assistant of his, in some way, was seized with a fit and fell against a lever which started the machinery, killing the man working on the roller. Two minutes examination of that laborer by the usual factory surgeon would have shown the danger of assigning him to work near machinery. The tragedy settled the question of physical examination for that company. It has been in force ever since, with the unanimous support of the men. It is a proposition that can be easily sold on its merits if the same patience and explanation are given that Mr. Young recited in connection with employment.

Training Foundry Executives

By Bruce W. Benedict *and* Robert E. Kennedy, Urbana, Ill.

The foundry industry in its broad outlines consists of three elements: Recorded knowledge of the foundry art; the human organization, by which this knowledge is translated into useful work; and the mechanical facilities of production. Although these elements are of fundamental importance, the second, or the human organization, outranks the others in vital character. If the recorded experience of the foundry art were eliminated at one sweep, much of it would remain in the minds of men, and beyond a pause for readjustment, production would go on as before. We can foresee that out of this wreck the fundamentals would emerge intact, since during the course of time they have become an integral part of thought and habit. And likewise, if the mechanical tools of production were suddenly wiped out of existence, men immediately would begin the construction of other facilities—doubtless of greater usefulness and efficiency, being less hampered by traditional restrictions.

On the other hand these opportunities for reconstruction would not exist should it become necessary to completely replace the entire foundry organization. Its physical form might be duplicated without difficulty, but after replacing man for man the organization would be little more than a hollow shell. Grant it the will to work and the necessary intelligence, still it would lack the ability to function. Weeks and months would not serve to replace the knowledge and skill laboriously and painstakingly accumulated by foundrymen throughout successive generations. Instead of a temporary pause for reconstruction, there would be a long period of inactivity until a new and self-trained force was able to take up the intricate task of foundry production. Unquestionably, the human element is the keystone of the foundry arch and any failure now to build wisely and permanently will endanger the future welfare of this great industry.

Happily we are emerging from that era when man was considered of no more importance than a machine. A few years ago the average foundry resembled a dungeon as much or more than it did a workshop. Then the heritage of the foundryman was dirt, dinginess, heavy tasks and pay unrelated to service. No more and in some cases less thought was expended on the worker as the producing element, than on the machine he used. He was, to use a familiar expression, a mechanical cog in a mechanical machine. There is nothing humiliating about being a cog—all of us are cogs—but as a human being and distinguished from the inanimate things of industry, every person is entitled to a place as a *living* cog in the machine that produces his daily bread. Just how much of the background of the labor situation today was born in the dingy interior of the old time foundry or shop cannot be stated with accuracy, but it is safe to say that there its broad outlines were laid. The radical had the form of his picture prepared for him, and all he needed to do was to supply the violent colors of exaggeration and prejudice to complete an appeal that has unsettled labor throughout the world. We, from our superior vantage point, are not misled by passion and untruth, but can we expect the worker living in a world of realities to pattern his thoughts in the same mold as ours? If we expect this in the face of the facts, we are credulous indeed. On the other hand, the bulk of labor is sound at the core and ready to follow the call of true leadership. The irresponsible radical has no chance ultimately with the real leader; yet radicalism, temporarily at least, is in the saddle. Has leadership failed? If it has not, to what can we lay the present condition of distrust and unrest? The foundry operator who has less influence with his workers than the radical preaching doctrines that lead to chaos, can with profit turn on the light of self analysis. More leaders, and better leaders, is the answer to the problem of industrial unrest.

The foundry organization as a whole, is composed of four groups, as follows:

Owners, and financially responsible operators.
Executives of the higher class.

Foremen and subforemen.
Workers of all classes in shop and office.

The first named group is small, comprising less than one-half of 1 per cent of all persons engaged in the industry. Financial or other considerations may overtop technical requirements in making selections for this group, so it is entirely possible to have men in this most important class who do not understand the technique of the foundry business. This type, lacking the basic knowledge of the work which comes from personal contact with it, normally may be expected to be more interested in the financial aspects of operation than in the human phases of it. This, of course, is the position of practically all nonresident stockholders. The examples of successful industrial ownership by men who have "grown up with the business" are so conspicuous as to prompt the suggestion that a broader extension of this type of ownership would go far toward bridging the artificial chasm that has in place grown up between employe and employer.

The second group, or executives of the higher class such as managers and superintendents, is relatively small in numbers but is of an importance equalled only by the first group. It consists of less than 1 per cent of the total number of employes engaged in the industry. Upon the men in this and the preceding group, numbering in the aggregate less than 2 per cent of the foundry organization, rests the entire responsibility for operation, for development and progress, and for conditions that affect the welfare of a multitude of people. In many instances these executives of high rank are in reality "the company" as they formulate policies and execute them. In every case the influence and power of this group is large, as it necessarily must be from the nature of industrial organization. Without doubt one of the greatest foundry problems today is the training of men for the higher executive positions. Although volumes have been written on this subject, and there are living examples of leadership of the highest type to pattern after, we possess no formula for this great task. "Leaders are born and not made" is a common saying that contains much truth. It is true insofar as *character* is concerned, since this funda-

mental element of leadership is the manifestation of the spiritual quality of man which is quite beyond the reach of human manipulation. But leaders are "made" when *knowledge* is added to *character*. The possession of *character* alone is not sufficient, nor is leadership attained by a mechanical process of acquiring *knowledge*. Regardless of the plan of training employed, the ultimate result will be naught if the basic traits of character are lacking. Leadership cannot be constructed on a foundation of sand.

Linking Education With Industry

It is not the purpose of this paper to discuss the entire topic of training foundry executives, but that phase of it falling within the realm of the technical school. It goes without saying that a technical training is not an absolute requirement in the training of successful foundry executives. There are other routes of attaining the end sought, but unquestionably the technical school is more direct and effective than any of those offered by the "school of hard knocks." A technical training develops the ability to think in logical and accurate terms; it stimulates the imagination and initiative; and enlarges the mental horizon until it includes a working knowledge of the fundamental laws of mathematics, science and engineering. It is pre-eminent as a medium for developing mental power. For a number of reasons, which space prevents mentioning here, it has not placed sufficient emphasis upon the development of those qualities which make for leadership. This fact is recognized by leading engineers and educators, and at present there is a pronounced tendency to remold curricula and teaching methods on lines that will make the technical schools ultimately more effective in this respect. A comparison of the courses of instruction as administered now and a few years ago by technical schools throughout the country shows that significant changes in educational methods are taking place. At the University of Illinois the reorganization of the courses in shop work to conform to modern industrial practice, is a typical example of this evolution in technical education. With the coming of the modern industrial era, with its revolutionary

changes in methods of management and of production, industry has been demanding increasing numbers of men especially trained for and qualified to carry on the diversified tasks of the new order of things. Men are wanted who understand the principles of management, modern methods of production, the standardization of manufacturing processes, scientific methods of paying for work done, specialization of labor, economics of manufacturing, the development and use of labor saving machinery, and above all, the ability to organize and direct working forces.

Are Natural Sources for Executives

While the technical schools are the natural sources of supply for recruits to fill these specialized positions, it is obvious they have not been equipped with facilities especially designed for this particular task. The situation was met in part, at the University of Illinois, by organizing the shop laboratories as a manufacturing plant, for the purpose of creating an industrial laboratory that would provide training in real problems of operation and management. Insofar as available resources would permit the shop plant was arranged to manufacture a standard product (an 8-horsepower, 2-cylinder gas engine) by generally accepted shop production methods. Operations were standardized, working schedules provided, improved facilities installed, stock and tool rooms provided, and production control methods introduced in all of the four departments of the plant. The aim was to create a manufacturing laboratory in which the students as workers and executives, would perform the various functions of production and of management incident to the manufacture of a commercial product. Since the year 1912, when the plan was adopted, the results have demonstrated that its ideals and working principles are fundamentally sound, and that it has great possibilities for further development. Close co-operation between industry and the technical school is essential to the fullest development of any plan of training, and it is in the hope of further stimulating the great interest of this association in technical training that the administration of the plan in the foundry department is presented here.

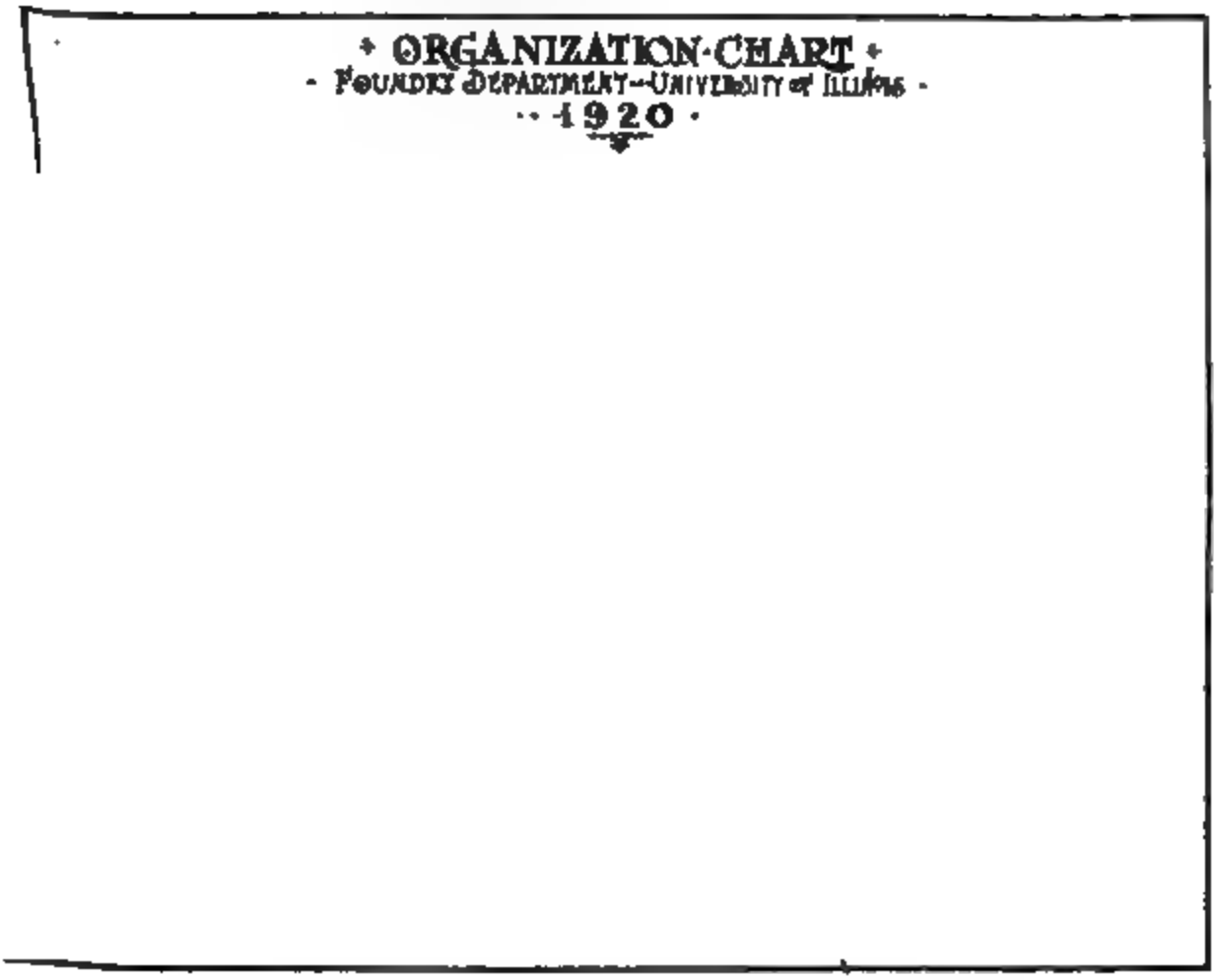


FIG. 1—ORGANIZATION OF THE FOUNDRY OPERATING STAFF IN EACH SECTION UNIT. THE STAFF HAS ENTIRE CHARGE OF OPERATION. STUDENTS ARE TRANSFERRED FROM ONE POSITION TO ANOTHER AT INTERVALS SO THAT AT THE COMPLETION OF THE TERM, EACH ONE HAS PERFORMED THE ESSENTIAL TASKS

The ideals underlying the course in foundry instruction are:

1. To promote knowledge of the principles of modern foundry management, by actual experience in directing the work of producing castings in a modern foundry by efficient methods.
2. To develop a working knowledge of modern foundry practice by performing the work of producing castings with modern methods and equipment.

The operation of the plan is simple. At the beginning of the school term an order is issued by the superintendent for a given number of gas engine parts. As all work operations have been standardized, this work order represents a total working time in hours usually well within the total student shop hours. It is possible for the order to be completed before

the end of the term, if the student managers plan their work as they should, and the student workmen attain the required efficiency of production. A definite standard of achievement is thus set up, which calls for the individual and collective effort of the entire class. The commercial foundry with all its problems of management and of technical performance, is transferred to the university laboratory. The training consists of the experience gained with real foundry operation.

Students Organized in Sections

After a short preliminary period of work at machine molding, coremaking and at the cupola, each of the four student sections (from 25 to 50 men) is organized as a complete foundry operating unit. Units are divided into two groups: (a) staff assistants, and (b) shop workers. The organization is shown by the diagram in Fig. 1. The staff plans and executes a production schedule to secure the completion of the required number of parts on the specified delivery dates. It issues work orders direct to the working group, and exercises the functions of foundry manager, foremen, inspectors and clerks. The working group do all the work of molding, coremaking, cupola charging, pouring, cleaning, etc. General supervision is exercised by the foundry instructors who act as superintendent and assistant superintendent, but their part is instructional only. They assume no responsibility for operation.

Students are transferred from one position to another at intervals, so that in the course of the term they perform all of the important tasks. The time is about equally divided between the staff and shop positions. Of the actual time spent at work on the floor, 60 per cent is devoted to coremaking and molding, while the remainder is occupied at the cupola, cleaning castings, and at general labor work. At the beginning of the term the assignments of each man are listed with accompanying dates, so the shift from one position to another is accomplished automatically and with no confusion.

As each work operation is standardized, it is possible to predict the amount of work which each unit should produce from week to week. Immediately after the number of available

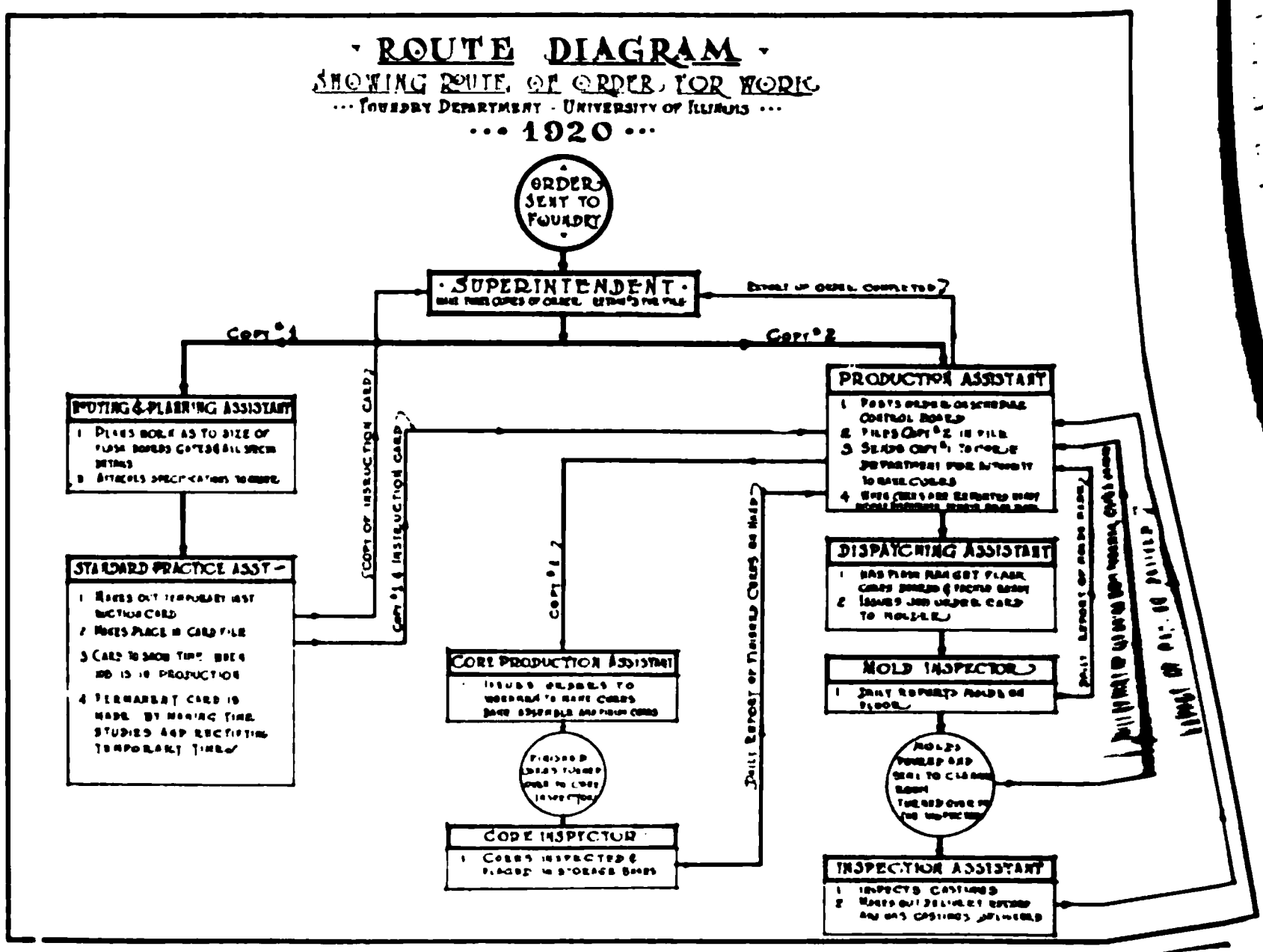


FIG. 3—DIAGRAM SHOWING THE DETAILED DUTIES OF STAF ASSISTANTS IN PUTTING THROUGH AN ORDER FOR WORK THROUGH THE SHOP

the production control board posted accordingly. A portion of this board showing the status of production for two sect on units at the close of the current week (Dec. 20) is illustra ed in Fig. 2. The board shows graphically the relation of act al output to expected output, and the status of work in the pr c- ess of completion. Foundry operators in search for fut re executives can make selections with little chance of error by observing the staff assistants directing the foundry activit es from this board. The marked contrast in the ability of in di- vidual students to organize and direct the work of others is immediately apparent here. None of the conventional colle ge examinations reveal this exceedingly valuable information.

Personnel of Foundry Staff

The staff is composed of the following members, calle d assistants: Production, mechanical, planning and routing, dis- patching, standard practice, materials, accounting and inspection -

The chief production assistant has entire charge of production. It is his duty to secure the required output by co-ordinating the activities of the various departments in his section. He is in effect the boss of the shop. He is directly assisted by the routing, dispatching, core production and materials assistants, each one of whom performs special duties as indicated on the diagram in Fig. 3. Tools, machines and facilities used in the production of work are looked after by the mechanical assistant. Inspections of and reports concerning molds and cores made in each section unit are the work of the inspection assistants. Reports of shop performance, and of attendance, and preparation of production charts are made by the accounting assistants (see Fig. 4). Standard instructions for the performance of all staff duties have been prepared in some detail so the more intelligent students take up the work of the various staff functions without difficulty.

The problems which the staff are called upon to solve are identical with those which are ever before the operators of commercial foundries. There are not only the usual routine problems of operation to struggle with, but also questions to settle regarding molding practice, use of pattern plates, mixing of iron and brass for various kinds of castings, the employment of molding machines, etc. These problems are not solved by the instructors with the students as spectators. Responsibility for operation is squarely up to the staff, and it is their task to work out solutions by the aid of the standard instructions and with the friendly council of their instructors. The average staff has a sprinkling of born leaders in it, who thrive under the load imposed by this responsibility, and who are fully competent to solve their problems with the aids at hand.

In common with other college shops, the foundry is not equipped with the most efficient facilities in all instances, for the universal reason—lack of funds. Modern equipment is added from time to time, making it possible to demonstrate its productive capacity, and also to compare the relative economy of various methods of performing the same operations. (See Fig. 5.) Every opportunity is taken to stage these demonstrations in order to stimulate the imagination of the student workers and

In addition to the regular staff and shop work, lectures are given on theoretical subjects such as properties of cast iron, cupola operation, molding machine practice, planning and scheduling of work, analysis of work operations, time study, etc. From time to time noted foundrymen (whenever they can be induced to come) and molding machine manufacturers give lectures on design of foundries, the production of castings, and molding machine operation. Lectures from prominent men in the foundry world are considered of great importance in this training, not only from their informational value, but also as demonstrations in personality.

Another feature of the course which has proved its worth is the systematic study of foundry trade literature, including magazines and catalogs. By a special arrangement with the publishers of *The Foundry,* students subscribe to this magazine for a part year. Reading assignments from its advertising and editorial pages are issued at intervals, and students report on this matter in note books. This brings the student in contact with the latest developments in methods and equipment. Foundry problems involving designs of foundries for the production of certain lines of castings, layout of core rooms, selection of equipment for specific kinds of work, etc., are part of the required work. Exhibits of foundry interiors and of equipment, from magazines and catalogs are displayed as shown in Fig. 6, to assist in the solution of these problems. The question of more efficient equipment for producing gas engine parts in the university foundry is a frequent matter of investigation. Reports are submitted recommending certain equipment selected from the available advertising matter, with arguments and figures to support the proposals made. It is obvious from these reports that the better class of students (the future executives) gain clear conceptions of the principles of management and production, and are able to apply this knowledge in the solution of practical problems.

Learns Necessity of Co-ordination

As the plan of instruction is identical in principle throughout the other departments of the shop laboratories, the stu-

dent acquires during the entire shop course a rather definite understanding of the fundamental principles underlying the production of goods. He learns by personal experience the necessity of co-ordination between departments and how failures in planning and in organization shatter production and decrease efficiency. When in positions of responsibility he observes the results of careless and indifferent work from an angle that did not appear to him when at the bench or cupola. His experiences, although in miniature, are the same as he would acquire under similar circumstances in industrial life.

Roughly about 5 per cent of all students taking the shop courses display conspicuous talent of leadership and at the same time possess the essential elements of character. The percentage varies in classes. Some section groups contain men of outstanding executive ability, while others have none of this type. Engineering students are a selected group, but at that, the percentage of them destined to fill high places in the management of engineering or industrial affairs is relatively small. This group, small as it is, is worthy of the highest educational advantages which the wealthiest nation on the globe can bestow upon it. No other group of young men exceeds this one in importance, not alone to industry, but to society which industry serves. As the leaders of tomorrow they must be prepared for the weighty responsibilities awaiting them. This task is a joint one for the technical school and industry to carry on together by sympathetic and effective co-operation. This association, as representative of the progressive spirit of the foundry industry is the logical agency for inaugurating a policy of co-operation that will enable the technical school to fulfill its largest mission. The hope is expressed that such a policy will be a subject for early consideration.

Discussion—The Training of Foundry Executives

MR. A. O. BACKERT.—Mr. Kennedy and Mr. Benedict are to be highly commended for the marvelous work they have undertaken at the University of Illinois. For many years I have heard foundrymen criticize the efforts that are being made by colleges and schools in endeavoring to train apprentices, to turn out shop executives, and in some experimental cases, to turn out molders. In very few instances, however, have the foundrymen lent their financial support, although they were always there with so-called moral criticism. I think the time has come when the foundrymen of the United States must get back of some movement, and not only morally but must get back of it financially, to help train executives that are so sorely needed in the foundry industry today. This great exhibition, occupying about 75,000 square feet of floor space, reflects more than anything else the tremendous evolution that is taking place in the foundry industry today. It is no longer a case of manual skill, muscle, etc., but it is a knowledge of equipment, and today there are very few men available who really know equipment. One organization of equipment manufacturers known as The Foundry Equipment Manufacturers Association, has taken it upon itself to issue a monthly bulletin dealing directly with the care of foundry equipment, and teaching how to handle and use it in the shops. Every day there is a call from some big foundry somewhere for men who know how to handle modern foundry equipment. The need for men who are up to date is more pressing today than ever before in the foundry industry. The development of foundry executives is the crying need of our modern casting industry. I believe that the American Foundrymen's Association, with some 1600 members, ought to make an investigation of the existing schools

or existing agencies that are trying to do this work, and I believe that an effort ought to be made to raise the necessary funds to back up such a movement.

While I am not authorized to speak on behalf of the Foundry Equipment Manufacturers' Association, I do know that at its meetings this subject has been frequently discussed, and I am positive that every member of that organization will see to it that any school that is selected to undertake this work under the auspices of the American Foundrymen's Association will get equipment, the most modern equipment available, at prices that represent cost, or probably less than cost.

MR. W. A. KNIGHT.—I gather from the remarks made here at first that foundrymen didn't want our graduates, that they were inclined to make fun of them, and they didn't measure up to expectations. Now if that is the case, there is no point to my offer, but I have felt that the foundry industries were not getting their proportion of college graduates. I thoroughly endorse what Mr. Benedict has said concerning shop work, and what we are trying to do, but the primary problem seems to me to be one of inducing a sufficient number of technical graduates to go into the field of foundry practice. As it is at the present, many graduates regard the work as being dirty and unpromising, with little opportunity for advancement or the exercise of fundamental engineering knowledge. As a consequence, students upon graduation prefer to enter the drafting room, machine shop, power plants or other of the numerous places open to them.

If we could get from each of the recognized engineering schools of the country but one or two of the mechanical engineering graduates per year to enter the foundry field, there would be a constant source of supply and influx of technically trained men into the industry. The founding industry would then be getting its fair proportion of the product of the engineering schools, which at present it is not getting. The colleges are not only willing but anxious to co-operate with the industries to bring about a more satisfactory situation. The initiative, however, rests with the foundry executives.

Several lines of endeavor might be suggested. The first would be for the foundrymen, through their natural organization, to prepare suitable literature, setting forth the present state of the industry, its needs, prospects for future development and opportunity for advancement for those taking up the work, this literature to be sent to the universities and distributed to the students. This could be supplemented by personal visits from a representative of your organization. Laying a case, personally, before the student is often more effective than the printed word. Then too, such a representative would keep in touch with and get first hand information on the work of instruction and no doubt would be very valuable to the schools in an advisory capacity.

Secondly, the American Foundrymen's Association might offer scholarships in engineering schools to a limited number of graduates of foundry trade schools or to apprentices who have shown worth and ability. This would be following out the army plan of training recruits for the Motor Transport Corps. In this the recruit is given a 16 weeks' course in the trade for which he seems best adapted. At the end of this period a limited number of the most promising are given another 16 weeks' course along the same lines, but more broadening in scope. Upon completion of the second period, a few of those who, having shown marked ability or capacity for leadership, are sent to an engineering school for a complete four year course. The point is that every recruit that enters the service has that prospect ahead of him. This not only makes for better recruits, but inevitably tends to bring to the top those best qualified for leadership.

Third, at certain recognized engineering schools a bonus of 50 to $100 could be offered to students who would specialize in foundry practice. Such students could specialize in the metallurgy of fuels, the ferrous and nonferrous metals, act as helpers or assistants to the foundry instructor, thereby keeping a close bond between theoretical knowledge and the practical application of such knowledge. They should put in the summer vacation in a good commercial foundry under the direction of some responsible man.

There is no reason why a student trained in the broad fundamentals of engineering and having specialized to the extent indicated should not upon graduation be a valuable assistant to the foundry superintendent or general manager and be able to take on responsibility at a satisfactory rate.

Report of the A. F. A. Committee on Industrial Education and Training of Apprentices

The government, with its vocational schools supported by the Smith-Hughes act, and the State Educational departments have been striving for some time to work out an industrial system whereby the apprentices in foundries could take advantage of the continuation schools. The many educational associations, the corporation schools and also the industrial plants have been trying to work out a system for their apprentices which would be a real benefit to all.

The committee on industrial education and training of apprentices of the American Foundrymen's Association for the year of 1920, was unable to carry out its proposed program due to industrial conditions and the universal unrest existing at the close of the war. It seemed wise to wait until the foundry industries were again working on a more normal basis before making investigations and suggestions as to the proper courses for apprentices.

The plan of the committee was to consider the entire processes of one specific manufacturing industry, viz: the production in a foundry of steel and malleable iron as well as the brass department of an automobile plant. We believed that in this way we could show the members of the American Foundrymen's Association just what was accomplished in a certain industry.

I was hoping that at this meeting we would be able to discuss the situation but due to lack of time and the many papers of extreme interest along other lines we have deferred the matter until another opportunity may be given when the commercial and industrial world is more settled.

We are glad for the encouragement received from foremen and placement managers in the foundry industries.

C. B. CONNELLEY, *Chairman.*

Discussion on Report

C. B. CONNELLEY—In the present social and economic life of this nation, there is nothing more important than industrial education or education for industrial life and achievement, and of all the types and forms of education now developed and conducted by the American people and nation, there is no type of education more important and necessary for the welfare of society than industrial education or education for industrial life and progress. This type of education is new as compared with the other and more formal types of education which have been maintained by nations and peoples for centuries. The present age and civilization demand, in addition to the standard academic and scientific education and in addition to the several kinds of professional education, this new and specialized form of education for industry. The very spirit of this economic and industrial period requires a special form of training for the men who are to engage in and to direct the industry in its many wonderful developments.

To the educators of the present day, the employers and captains of industry are now coming and are demanding of the a specific and more or less specialized education for the members of the present generation who are to become factors in the modern industrial organization and machinery. They realize that it is an economy of time and of money to have the younger generation receive the rudiments and an adequate preparation for industrial work in the schools, public and private, of our land. With this preparation given to the coming generation about to enter the industries, years of time and millions in money will be saved. It is, therefore, neither unreasonable nor illogical that employers of labor should make this demand.

The working classes, male and female, are also coming forward and are demanding of our public and private educators that industrial education shall be furnished to fit them more specifically for economic and industrial life

nd to enable them to increase, in these days of high rices, very quickly their economic value and earning ca- acity. I need not say more to convince you that industrial ducation has come to stay and is now receiving and will ontinue to receive, as time goes on, more and more careful nd detailed attention from every one interested in and en- gaged in the education of mankind.

It is not only important, but it is absolutely necessary that apprentices entering any of the industrial trades or occupations receive a careful training, liberalizing and general to a certain extent, and yet highly specialized and specific so that the apprentice may quickly become an expert in his special phase of industry, while yet possessing a broad vision nd understanding of the entire field of his industry and of ll industry. It is necessary, therefore, that the apprentice hould have a certain amount of definite academic training in nglish, mathematics, history and economics. English must included in this training so that the apprentice will be le to think clearly and to express himself accurately and finitely in writing, but more especially in his oral utter- es. The correct and accurate use of language, whether speech or in writing is so closely connected with clear and se thinking that it is practically impossible to have one hout the other, because in the last analysis language and ught are almost identical. English, therefore, and espe- ly oral English, must be included in the training of the rentice.

believe that you will agree with me, without any ques- , that mathematics must be a part of the apprentice's ication, both for its disciplinary value in close and correct nking and for its practical value in the daily computations industrial and commercial work. It is important, however, t the mathematics, given to apprentices, be carefully and sely selected and adapted to the needs, requirements and titude of the apprentice himself.

In order that the apprentice may have a thorough under- tanding and an illuminating vision not only of his own in- dustry, but also of all industries and of the economic world

in which he is an essential factor, it is necessary that the apprentice be thoroughly trained in the basic principles of economics. Without this training, the apprentice merely gropes and flounders in a world of gloom and drudgery. With this training the apprentice can receive an insight into the industry.

Pouring, Gating and Feeding Steel Castings

By R. B. Farquhar Jr., Indianapolis

Three broad topics are involved in the title of this paper and the author has made only a modest attempt to merely skim the surface, as it were, of the subject. It is hoped that these skimmings may contain more than slags, dross or impurities, and that they may rather contain some elements of a reagent, physic or alloy that will purify, cleanse and solidify into real ingots of better practice.

Only when the general principles underlying the handling of molten metal are clearly understood, can satisfactory results be accomplished and the making of steel castings be reduced to something approaching an exact science. When these principles are not understood and applied, trouble is sure to be encountered, and producing steel castings becomes merely a haphazard rule of thumb practice. Under present conditions, foundries wherein guess work and "trust to luck" methods prevail cannot survive. There undoubtedly still are many foundrymen who do not recognize nor understand that many of these problems exist; hence, they cannot accomplish their solution. There are other foundrymen who do understand them but do not apply a solution. There are still others, let us hope not in a small minority at the present time, who do generally recognize the existence of many of these nice problems, and who have successfully encompassed their solution by the consistent application of scientific knowledge. To the latter class only will belong the spoils of victory in the future.

Pouring Ladles

Volumes might easily be written on the many types of ladles used, and the methods of transferring the metal from the spout of the furnace to the mold, but it is the purpose of the author to only briefly summarize these types, and refer casually to ladles and ladle practice.

Bottom pour ladles are almost universally used where

large volumes of metal are handled, although many such ladles are used where heats as small as 3 tons are run. For large open-hearth castings, bottom pouring prevails whether the furnaces are acid or basic lined. Bottom pour ladles are used almost exclusively in pouring basic metal from electric furnaces even though the heat may weigh only 2 or 3 tons on account of the great difficulty in thoroughly skimming off the powdery carbide slag from lip, teapot or bull ladles. Among the advantages of bottom pouring may be mentioned the fact that the coating of slag which covers the metal acts as a protection from drafts and from hasty chilling, and on account of the stream being drawn from the bottom of the ladle through the nozzle, the entrained slag permeating the bath of metal just tapped is constantly rising to its surface away from the exit. Thus the metal will remain hot much longer, and far less slag is drawn into the mold, and particles of slag which rise to the surface after skimming lip pour ladles are not nearly so prevalent in the castings. The common trouble with nozzles and stoppers cutting out, leaking or breaking are often cited as serious disadvantages against bottom pouring. These troubles are real, but they can generally be practically eliminated by careful study, by experience, and by assiduous attention to the most minute details. I have seen abominable bottom pour ladle practice in large shops which had been in operation for decades because of the failure of those in charge to really get to the bottom of bottom pour ladle troubles. I have also seen, in more than one newly established shop, these bottom pouring troubles entirely eliminated due to the experience of the man in charge and his persistent and critical attention to the subject. Every time a leaky stopper or other stopper trouble occurred, he sought an exact diagnosis of the cause and spared no expense to prevent a recurrence. There is the additional cost of stoppers, nozzles, stopper rods and sleeves to be considered in connection with bottom pouring, and usually the amount of labor and skill required is greater. Where a great deal of side floor work is made which must be poured from shanks, either bottom pouring or lip pouring may be used from the large or main ladle to the shank ladle. After a con-

siderable study, and a great many tests, we have come to the conclusion in our foundry that under our conditions at least, bottom pouring from a 3-ton ladle into shanks has many advantages to offset stopper troubles, cost of nozzles, stoppers, stopper rods and sleeves, although the extremely hot acid electric metal which is necessary to successfully pour the light, thin-sectioned side floor castings from shanks sometimes causes an actual fusion of the stopper rods. By using bottom pour ladles into shanks, the metal stays hot longer, is freer from slag, there is no labor involved in skimming the large ladle, thinner castings may be expected, and less skull in ladles and shanks. A thorough trial of shanking side floor work from lip, teapot and bottom pour ladles has resulted in the adoption of the bottom pour method for very hot electric steel as our present standard practice at least.

Use of Lip Ladles

Lip ladles larger than 4 or 5 tons, due to the weight of the metal involved, are not commonly used. For heats of this size they usually are only used for converter and electric steel of very high temperature. Lip pouring is practically never done so far as the writer is aware with large quantities of open-hearth metal, due to the rapidity with which the metal chills after skimming, thus losing its fluidity and causing bad ladle skulls and misrun castings. With hot converter metal or acid electric steel, lip pouring is perhaps most common due to the high temperatures prevailing, extreme fluidity of converter steel, and the comparative ease with which the slags can be pretty thoroughly removed from the surface of the metal. Due to its high temperature, it is quite common in handling converter metal to hold ladles from 5 to 10 minutes after skimming the slag off before pouring castings if the latter are heavy or of thick sections. This holding is not only highly desirable, but if tested work is being made it is necessary to give the slag time to float to the surface, the entire bath being permeated with the finely divided slag particles incidental to the converter process. When converter metal is given this holding period, which is merely an incidental part of good converter practice, it will be found to meet all physical tests expected of

it. When pouring such metal from the lip, this entrained slag is constantly rising to the point from which the stream is drawn instead of away from such point as is the case in bottom pouring. This difference in the conditions existing inevitably shows up in the quality of the castings poured by the two methods in physical tests.

Using Teapot Ladles

The use of teapot ladles is quite common in handling converter or electric metal, and most of the objections to lip pouring are overcome insofar as slag is concerned whether acid or basic. The protective covering of the slag previously referred to is present and since the stream is drawn from the bottom of the bath, the slag is rising away from the exit and castings free from slag particles may be expected. Teapot ladles, however, will give trouble by the spouts freezing up before pouring is completed unless the metal is very hot as is commonly the case in converter and electric steel shops manufacturing small, thin-sectioned castings. Great care and haste must be exercised if heavy skulls and high labor costs for chipping are to be prevented and frequent relining of spouts avoided. Even with teapot ladles, skimming in the spout is often necessary due to the constant accumulation of slag around the surface of the spout.

Small bull ladles of 1000 to 2000-pound capacity are very common in electric and converter steel foundries, they being filled from a main ladle containing the whole heat, or in some cases, from the spout of the furnace or the mouth of the converter. On account of being small, they are much easier to skim thoroughly, and can be used in pouring very small molds close to the floor without serious skulls remaining in them if the metal is very hot and they may be used many times without relining or chipping.

When we come to a consideration of the mold to be poured, our problem involves the size of the mold or volume of metal; the temperature of the metal in the ladle; and the time necessary to transfer the metal from the ladle to the mold to get the

best results. Therefore, volume, temperature and time are the prime factors.

For a given volume of a certain temperature, the time required to make the transfer to accomplish the best results may vary greatly for different castings. By this it is meant that some castings weighing 2000 pounds should be poured very much more rapidly than others of the same weight due to their shape, area or section. Furthermore, of two castings weighing 2000 pounds each, one might require very much hotter metal than the other due to its shape, area or section. Just the right amount of elapsed time in the transfer from ladle to mold can generally only be determined by judgment or experience, and since it depends upon so many factors, very often the only way to find out this time is by the costly method of a test or tryout, often at the expense of a lost casting. With very large castings, this is of course expensive and must be avoided, and it is to be regretted that there are no laws, so far as the author is aware, which can be laid down and absolutely applied for the guidance of the foreman upon whom the responsibility rests

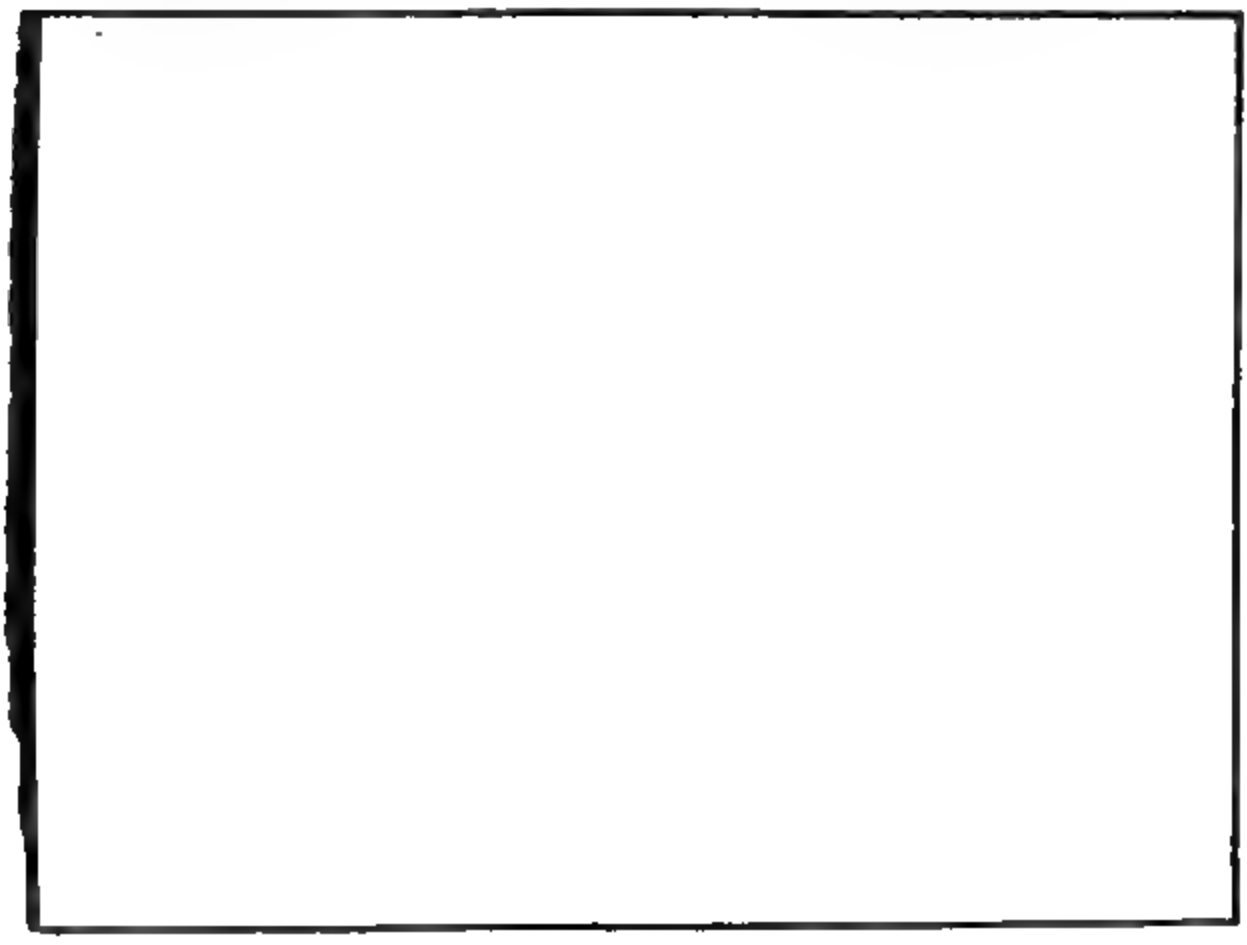


FIG. 1.—LARGE ARMOR PLATE INGOT MOLD

for obtaining perfect castings. Actual elapsed time for pouring different castings from the largest to the smallest may, of course, vary from a few seconds to as much as 25 minutes in exceptionally large pieces. The latter extreme time was found necessary to pour some steel castings that weighed over 300,000 pounds each. Four open-hearth ladles pouring simultaneously through three 5-inch diameter brick runners were required.

Producing Large Steel Castings

Probably the largest steel castings ever produced in this country are the ones referred to. They weighed between 350,000 and 400,000 pounds each and required about 90,000 pounds of feed metal as much as one and one-half hours after pouring. The risers did not solidify until three and a half hours after pouring. The copes were not stripped off these castings until 24 hours after pouring, and the annealing treatment took about 10 days.

Actual pouring time, taken from the author's notes, of the large armor plate mold shown in Fig. 1, is as follows:

Ladle	Pounds	No. 1 Runner	No. 2 Runner
A	135,000	1:28 to 1:34 p. m.	
B	135,000		1:29 to 1:35 p. m.
C	45,000	1:34 to 1:37 p. m.	
D	45,000		1:35 to 1:38 p. m.
Total	360,000	Elapsed time—	1:28 to 1:38 p. m.
Excess left in Ladle "D," 5 per cent...	18,000	10 minutes to pour	
	342,000		
Added	5,000	Feed at 2:08 p. m.	
Added	3,000	Feed at 3:30 p. m.	
Total weight.....	350,000	Molten, 2 hours, 2 minutes.	

The vents in the large cores of these castings retained their color 10 days after they were poured, and these castings were not stripped until the fourteenth day after pouring, at which time they showed a dull red color.

Pouring Small Molds

When pouring very small side floor or snap flasks from shanks it is usually highly desirable or necessary to get the metal into the molds in the shortest possible time and at the highest practicable temperature in order that it will run up

and completely fill all portions of the piece. If a few seconds are lost in pouring such small castings, a misrun job may result. For very light, thin sections, the high temperature of the metal is no detriment for since it solidifies so rapidly, it will not burn into the sand and cause difficulty in cleaning as would be the case with large castings poured too hot. If the area is not too great, and the casting is properly gated, the high temperature should not be a detriment in causing cracks. On the other hand, many large castings should be poured just as cool as possible, and hence as slowly as the temperature of the metal will permit and yet take completely and fully the impression of the molds. Also when poured cold and slowly, the metal will not burn into the sand so much, and there is less liability to check or crack. Just as the too rapid pouring of ingots with too hot metal may be the frequent cause of cracks, so may similar conditions be the cause of cracked castings. The author has seen cast steel cylinders practically 10 inches outside diameter and 6 inches inside diameter by 58 inches long crack badly when poured fast with hot metal from the first part of the heat, when the same cylinder showed no sign of cracks when poured slowly at the end of the heat with cooler metal.

Temperature Test of Molten Metal

Since the rate of pouring a given casting should be arrived at partly by a knowledge of the temperature of the metal at the time of pouring, it is quite important that the approximate temperature should be determined and made known to the man in charge. By the use of a spoon test for temperature, immediately prior to tapping, a very accurate line on the condition of the metal may be given to the man directing the pouring. In the foundry under the author's supervision, this practice has become established to such an extent that the foundry foreman will give the head melter an order for the metal desired, whether for light floor work or heavy main floor castings, in terms of the number of seconds before solidification of the spoon test. If the heat is ordered for 80 seconds for side floor work and the spoon test shows only 65 seconds, the man directing the pouring has

pretty good advance information that he will have a good many misrun castings on the side floor. We have established the practice of pouring the side floor work with shanks taken from the bottom-pour main ladle containing the whole heat, and if the initial temperature is not as high as desired, part of the side floor may be poured from shanks and the remainder of the metal in the main ladle be bottom poured into heavy main floor work. It is the author's opinion that not near as much attention is paid to metal temperatures and pouring conditions by the average foundry foreman as the subject deserves, and as a result, the percentage of defective castings, where much small work is involved, is very much greater than might be the case were this important phase of foundry work given more critical attention and intelligent study.

Thus we see that the most desirable elapsed time in which to pour a given mold may vary from a few seconds for snaps to 25 minutes in the case of the large casting briefly described. There are an infinite number and variety of exceptions that require study, ripe experience and often keen judgment. Even though the temperature of the metal is pretty well known, the man in charge must estimate how long he can keep it in the best condition to pour the molds of a given heat, and it will be necessary to select the order in which the various castings should be poured according to their comparative weight, area and section, as well as their intricacy, liability to crack, check, etc. There is a nice balance to be determined, a great many factors are involved, and perfection of accomplishment is forever just out of reach.

Principles of Gating

The speed or rapidity of transferring the metal from the ladle to the molds is controlled by the size of the runners and gates, and these must be determined for large castings from a knowledge of the laws governing the flow of liquids with given heads, and the desired times arrived at. The most desirable time in which to fill a given mold of large volume is very much a matter of judgment and experience based on the factors already referred to, such as section, area and

total volume. The gates of various castings may vary from a fraction of a square inch in cross section to as high as two 7-inch diameter clay pipe runners with an aggregate section of 77 square inches for large molds. Gates may be single, double or multiple, and in large castings, the gate may be what is known as "straight," "whirl," or "fountain." For high molds of large volume, the same gate or runner may have two outlets, one at the bottom of the mold, and one about half way up the mold through which the metal will enter when it has risen to that height as is indicated in Fig. 1 at *A*. This runner *A* half way up the large mold weighing 350,000 pounds is highly desirable, since it will permit the hot metal to enter over the surface of the mold at that point at a time when the rising metal in the mold may be beginning to solidify and chill or crust over. The entrance of hot metal at *A* will thus make a smoother casting, and will run up better from *A* to the top of the casting, Fig. 1. It will also permit the metal at the bottom of the casting to begin to cool ahead of the metal at its top from which point feed is drawn. The gates on small castings may be Y, fan, horn or straight, according to the design of the casting involved. They must be so arranged that they will not cut, wash nor trap air. Gates should be placed so that they will introduce the metal into the mold at the spot least liable to cause cutting or disturbance of cores or sides of mold, objects not always easy of accomplishment. Consideration must be given to liability to hot or cold cracks upon solidification of the metal and the cooling and shrinking of the casting. Attention must also be paid in locating gates to the feasibility of their removal in the cleaning department with the greatest ease and least expense. Oftentimes gates may be designed and used as feeders for small and medium sized castings (see Figs. 14 and 21) and occasionally feeders or risers may be used for pouring, thus eliminating the necessity for other runners and gates.

The successful feeding of castings can only be accomplished by a thorough knowledge of the physical laws which govern the solidification of different masses of molten metal.

The study of relative masses adjacent to each other is of fundamental importance. We again find, as in the case of pouring already explained, that the factors of volume, temperature and time are the ones to be considered. These physical laws, in the opinion of the author, may be briefly summarized somewhat as follows:

1. Two equal masses of molten metal of the same temperature and approximately the same area will solidify at the same time providing the containers or molds are of relatively the same radiating and conducting power.

2. Of two equal masses of molten metal, the one with the higher temperature will solidify after the one of lower temperature. The former will require more feed after it has been poured, all other factors such as nature of container, chills, etc., being equal, because the one of higher temperature has a far greater drop to the solidification point, and it will require more feed after being poured at such higher temperature due to its lower specific gravity or conversely due to its greater volume per pound; hence its greater shrinkage in passing from its higher temperature to the temperature of solidification.

3. Of two equal volumes of molten metal of equal initial temperatures, the one with the greater area per pound of weight will solidify first because of the greater surface exposed to the conducting and radiating effect of its container.

4. Of two castings of unequal volume, the one of smaller volume will solidify first provided the approximate areas and temperatures are the same, and the radiation through the container equal.

5. Of two castings of the same initial temperature, of the same area but of unequal volume, the one of greater volume may solidify before the one of lesser volume through the introduction of artificial means such as "chills" to accelerate the cooling of the larger.

6. The percentage of metal to feed two castings of the same volume may vary greatly if such castings are of radically different area and different section, the one with the greater area and thinner section requiring less feed after pouring but before solidification than the former.

Note.—The distinction should be borne in mind between the amount of metal required to feed a casting to get it perfectly solid throughout and the amount of riser or top discard remaining after solidification. The one may differ very widely from the other, for by perfect feeding, the amount of actual riser or top discard remaining after solidification may be very greatly reduced if feeding conditions are well balanced.

Using Chills for Casting

Referring to the first law, the introduction of chills may be used to accelerate the cooling and hasten the solidification of the one mass or the other as may be desired. In regard to the second law, the writer frequently has seen many striking examples of this condition in pouring large castings. Extreme

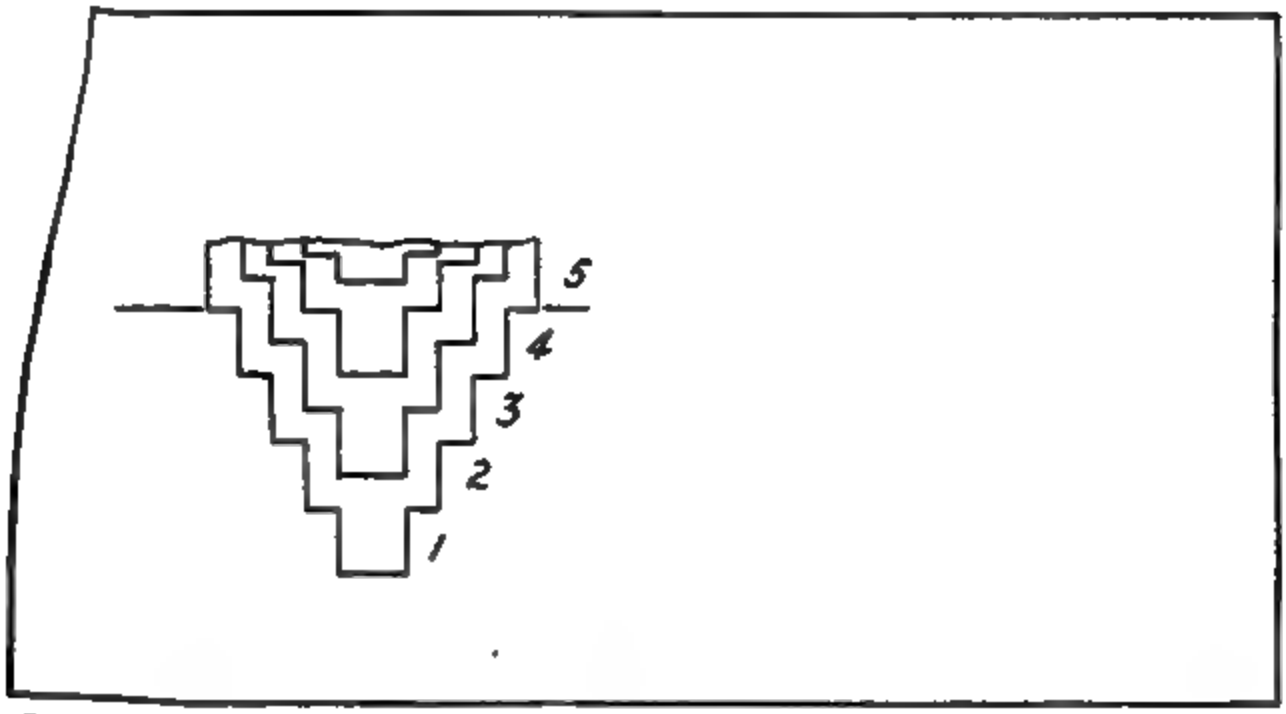


FIG. 2—DISPOSITION OF SECTIONS TO ACCOMPLISH PERFECT FEEDING FIG. 3 CONDITIONS IN CASTING WHICH WILL NOT FEED PERFECTLY, A CAVITY WILL FORM AT *a*

cases have been noted in pouring ingot molds weighing from 150,000 to 350,000 pounds each. He has seen such castings when poured very hot require from 15,000 to 25,000 pounds more of feed metal after the mold was originally filled, and before solidification than the same castings required when poured with very cool iron. In each case the weight of the remaining riser or top discard after the castings had become cool may be the same, but the amount of feed metal required to make the

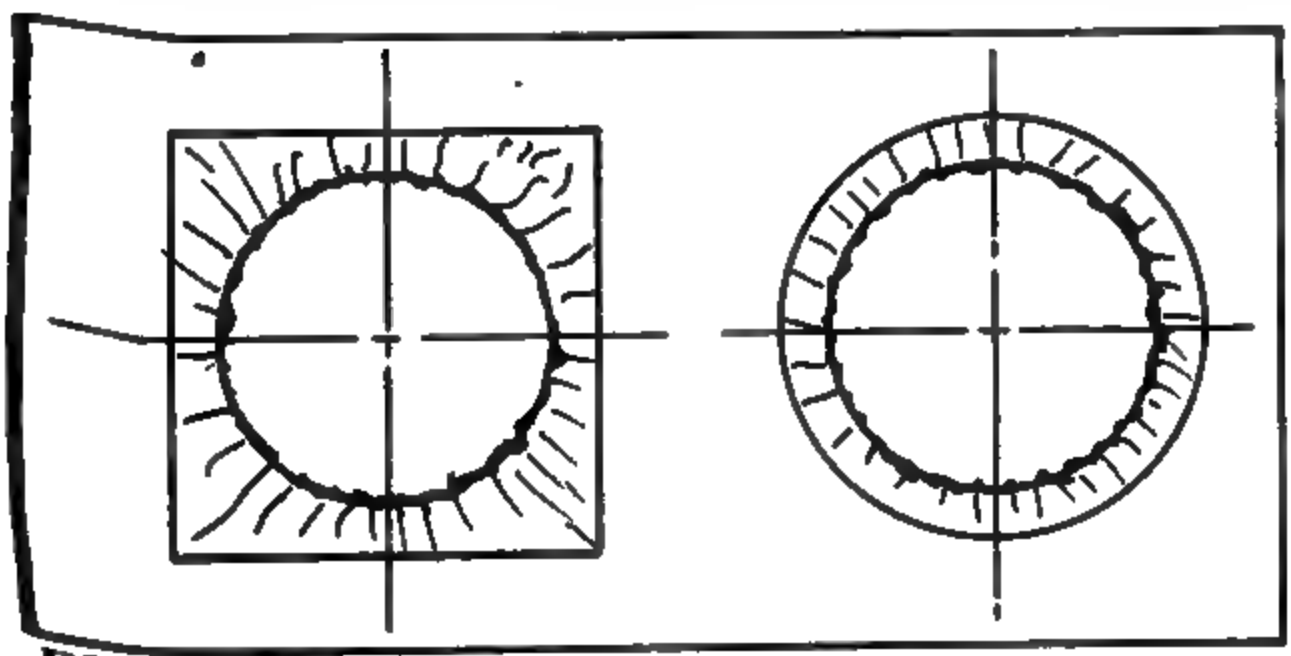


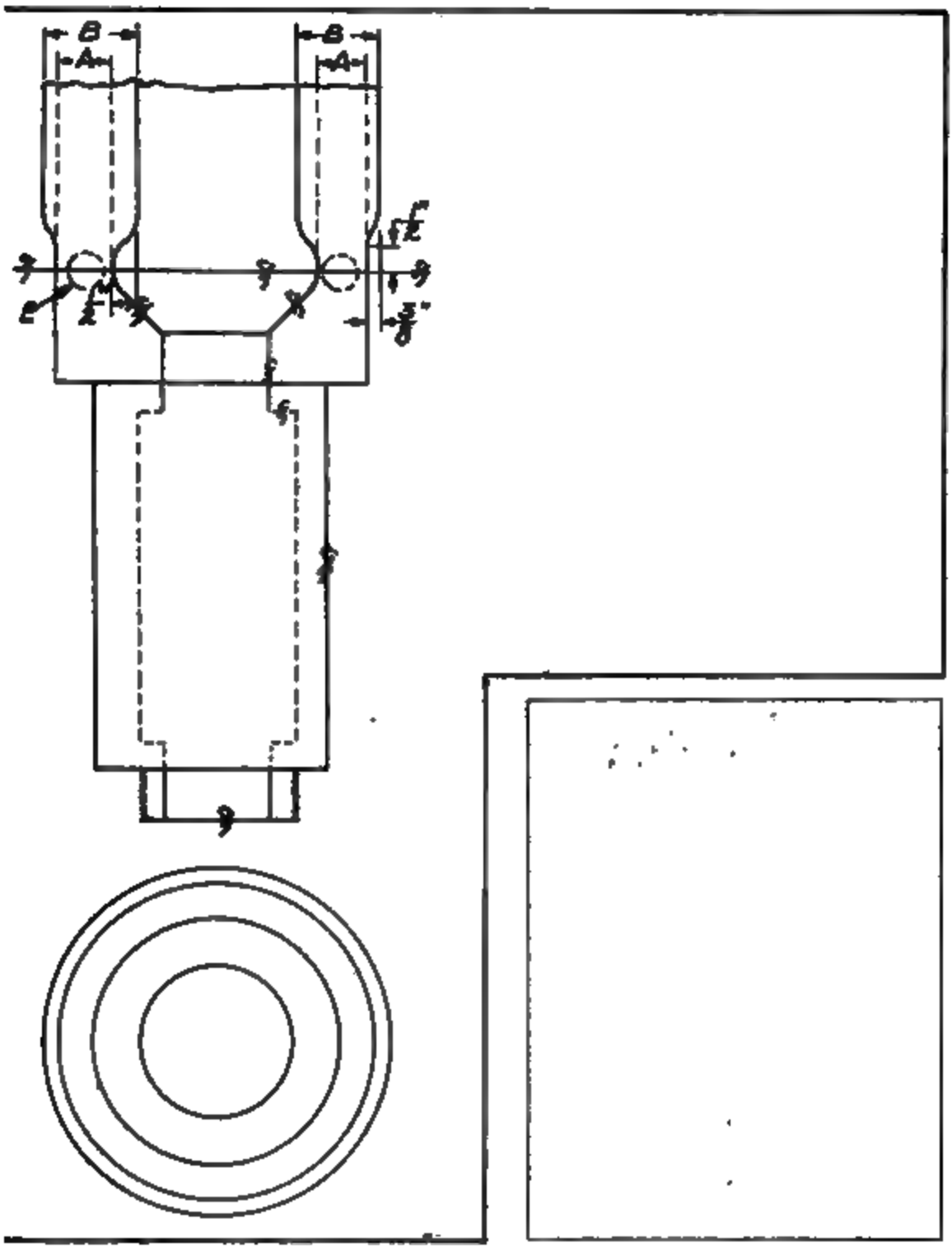
FIG. 4—CROSS-SECTION OF SQUARE RISER. FIG. 5—CROSS SECTION OF CYLINDRICAL RISER

castings solid differed tremendously. He has seen the same difference prevailing in pouring very large steel castings.

Referring to Law No. 3, a casting such as is shown in Fig. 8 will solidify much quicker than the casting shown in Fig. 9, even though their weights be about the same because of the very much greater radiating surface of the mold and the greater area over which the molten metal is quickly distributed and chilled. Theoretically, these two castings might be expected to require the same amount of feed, and perhaps they do, but the molten metal of casting No. 8 is shrinking very rapidly while pouring and when solidification has taken place, the actual amount of top riser or discard remaining is only about 10 or 15 per cent, whereas in the case of Fig. 9, the molten metal in the mold is much longer in solidifying after having been poured and hence a much larger riser or reservoir from which to draw feed as it cools will be required, and the amount of top discard remaining may be as much as 30 or 40 per cent. There is another condition prevailing, however, in castings such as Fig. 8, that should not be overlooked. Where thin and thick sections are adjacent, it is possible that certain thin sections may shut off some adjacent thick sections from feed; hence, such adjacent thick sections will have shrinkage holes that cannot be fed. A casting in which such a condition prevails will lack the density possessed by a casting that has been perfectly fed in all portions, as that shown in Fig. 9.

Referring to the fourth law; if the area of the heavier casting is far greater than that of the lighter, it is quite possible that the former may require a much smaller percentage of feed for its weight than the latter because of the accelerated cooling of the heavier casting due to its radiating surface. For example, the casting in Fig. 8, although much heavier than the gear blank shown in Fig. 7, undoubtedly will solidify throughout sooner than the gear blank although the latter is much lighter than the former.

The fifth law is fundamental and must be constantly borne in mind in feeding castings. Undoubtedly in the majority of castings there are certain thick sections that are inaccessible



. 6.—SECTION OF DUMMY PROJECTILE SHOWING EXAMPLES OF RISERS. FIG. 7—SIMPLE FEEDING OF GEAR BLANKS

d hence lack solidity unless their cooling is accelerated by ificial means. Reference to Figs. 11, 12, 14, 16 and 19 will w examples of such sections. Many such thick sections l either possess shrinkage cavities or must be artificially lled if they cannot be fed directly as was done for example

to feed, and which will solidify after other thinner sections, in the case of the bottom flange *A* of Fig. 9 with a lump feeder.

Referring to the sixth law, the actual top discard by the free use of chills may be greatly reduced and actual shrinkage cavities and lack of density in thick sections may be prevented. Years ago the well known practice of some steel foundrymen of reducing the size of risers and "necking" them so that the castings would appear solid under the riser and yet would be hollow inside was the cause of much jovial comment on the part of some of their competitors, and so far as the author is aware this practice is not tolerated in these days. The author is satisfied that by the frequent use of chills in our own foundry we have reduced the percentage of top scrap by as much as 5 or 6 per cent and increased the amount of weight going out over the scales in proportion, not to mention the decreased weight of castings returned.

Feeding Large Steel Castings

In feeding large castings, the use of charcoal, soapstone, sawdust and other such substances on the top of large risers assists in feeding by retarding the freezing up or solidification of the riser. By the manful use of iron rods pumped up and down in risers of heavy castings, feeding may be assisted, the riser neck thus be kept open, and the metal prevented from freezing before it settles into the mo'd. The use of feeding rods in the hands of a strong-armed laborer or molder is of great assistance in feeding both iron and steel castings of large size which may take many minutes to solidify throughout.

The percentage of top discard to the weight of castings may vary greatly for different classes of castings and in different shops. In very small gated castings, the weight of gates, runners and risers may be 200 or 300 per cent of the weight of the casting. In much heavier castings, the weight of the risers may vary from 8 or 10 per cent of the weight of the casting all the way to 50 per cent. How to accurately determine the correct amount of riser necessary to perfectly feed given castings is often quite a nice problem, but it can usually be satisfactorily solved by study and experience, leaving of course a safe margin of allowance for variation of pouring tem-

eral sections will solidify in the order of the numbers indicated, that is, 1, 2, 3, 4, 5, the top scrap solidifying last and containing the shrinkage. Fig. 3 shows graphically the conditions which prevail in a casting that does not feed perfectly and hence possesses a decided shrinkage cavity at *A*. The casting poured in the position of Fig. 3 will be solid in its upper half which will solidify as indicated by the numbers, but the lower half will be shut off from the source of feed by the solidification of the central sections, 1 and 2, forming the shrinkage cavity at

FIG. 9 TOOL POST CASTING GATED FOR MINIMUM DISCARD

point *A*. If these illustrations are kept clearly in mind and the various sections of different castings adjacent to each other are analyzed in the light of these two figures, much shrinkage trouble may be prevented. While the central portions 1, 2, 2, etc., of Fig. 3 will solidify and cut off feed from the source, it must always be borne in mind that by artificial means the solidification of the lower portions, 3, 4, 5, may be accelerated to such an extent that they would solidify before 1, 2, etc., and hence be fed solid. By a study of Figs. 2 and 3 and the laws previously outlined, the fundamental principles of feeding may be understood and applied. The practical application of these principles to the castings made each day, becomes a most interesting, important and fascinating subject. With the infinite

cretion of the molder, nor should it always be left entirely to the foreman in charge, be he ever so capable. Another very apt adage that "Two heads are better than one," might be changed to read, "Four heads are better than two," meaning the heads of the men responsible for production in the foundry. The superintendent should be encouraged to call into conference the patternmaker, the foundry foreman, the chief inspector, and very often one or more molders in mapping out the way in which certain jobs can best be made, and deciding upon the best method to pursue. Frequently the solution for a most knotty and perplexing problem has been suggested by a molder or patternmaker. When the combined knowledge of all those in charge can be concentrated on a foundry problem, involving these subjects, it is apt to be solved satisfactorily. When a suitable method has been arrived at, some routine should be established whereby the decision is recorded and handed down on the records for future reference and benefit. The photographing of such castings, painting of patterns different colors to indicate the location of gates and risers, their size, etc., are valuable aides to foundry operation.

Risers Should Be Cylindrical

Where space will permit the shape of a riser should usually be a true cylinder, since solidification takes place in a circle as shown in Fig. 5, whether the riser is cylindrical or square as shown in Fig. 4. For this reason the corners of a square riser are largely wasted metal, as indicated in Fig. 4. A square riser, 4 x 4 x 6 inches high contains 96 cubic inches for feed and a circular riser of the same diameter as a side of the square and the same height, contains 75.4 cubic inches, a saving of 20.6 cubic inches of top discard. The round riser will undoubtedly feed the casting just as effectually as the square riser greater in size. In the author's opinion the most effective height of risers has generally become established as one and a half times their diameter; therefore a 6-inch riser need not be more than 9 inches high, a 12-inch diameter riser more than 18 inches, a 20-inch 30 inches high, etc., to get the maximum result for the minimum expenditure.

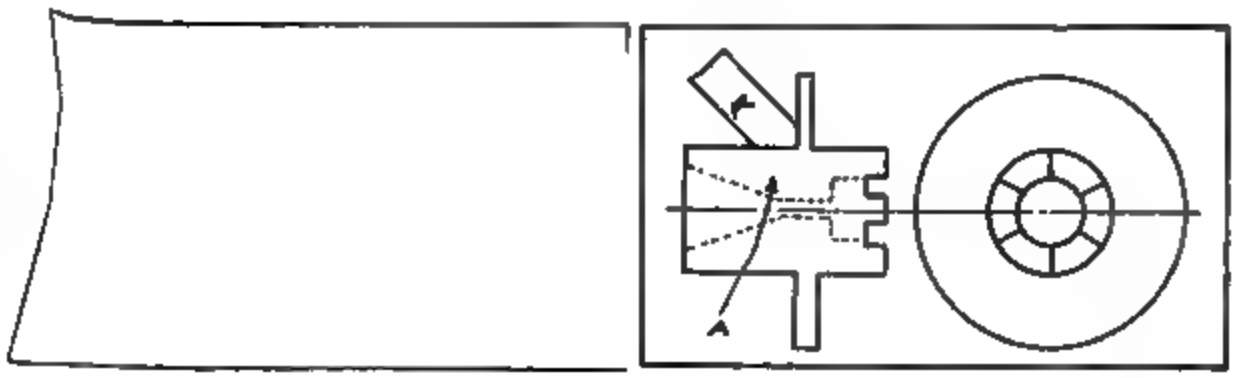


FIG. 11—HUB CASTINGS OF THICK SECTION. FIG. 12—SECTION OF HUB CASTINGS

Risers may be elliptical, annular or irregularly shaped according to conditions. If it is necessary to make them square or rectangular where they join the casting, they may be necked to cylindrical in shape above that point. Several examples of risers are shown in Fig. 6, which represents a dummy projectile. The specifications called for machined surfaces all over outside and inside and all surfaces had to be free from defects. The best way to make these castings was the subject of a great deal of study, and the best results were finally accomplished by pouring them from the bottom with an annular riser indicated by *BB*. To pour them with the threaded end up would have not given sufficient area for an annular riser at that end, and the thick section of metal at the other end would not be fed unless by the use of a lump riser, which was undesirable. To pour them on the side meant that they would be harder to feed, the riser would be more difficult to remove from the cylindrical surface, and the cope side of the castings would possess some slag or sand holes which would cause their rejection. By referring to the several possible methods, the annular riser method *BB* meant that the cope end of the casting was entirely open, and all dirt would float to the surface, and all parts of the heavy section at the top would be thoroughly fed. The use of the risers *CC*, *DD* and *FF*, might accomplish the same results, but not with the same certainty, and they were more difficult to place and remove. The actual percentage of top discard with the annular riser *BB* was more easily controlled and reduced. By making the annular riser the same width as the casting, as indicated by the dotted lines *AA*, insufficient feed was provided and shrinkage holes occurred at *E* below the finished lines.

To show the practical working out of some of the general principles of correct feeding which the author has endeavored to point out, the following typical examples may be of some interest.

Fig. 7 illustrates a very simple case of adequate feeding of plain gear blanks and Fig. 8 is an example of a casting with thin walls and large area exposed to the mold, causing it to solidify so rapidly that little if any feed is necessary after having been poured. In Fig. 8, the risers are little more than what might be called "flow offs" or "pops" and which only amount to 8 or 10 per cent of the weight of the casting. The gear blanks of Fig. 7 do not weigh nearly as much as the steel flask of Fig. 8, and yet the blanks will solidify later than the flask if poured at the same time and the same initial temperature, and will take far more feed after pouring but before solidification, therefore, have much more top discard. (See Law No. 4 regarding rates of solidification.)

Fig. 9 shows a tool post successfully gated and fed to obtain perfect castings with a minimum of discard. These castings are machined all over, outside and in, and both flanges then are drilled full of holes so that if defects or shrinkage exist they are certain to be brought to the light of day. Fig. illustrates exactly the condition to be met in the casting shown in Fig. 9 In the illustration, the casting to the right with gates and risers removed is inverted when compared with the casting to the left without them removed. The center riser on top of flange *B* to the left will not feed and take care of the lower flange *A* because the neck between the flanges at the center of the casting will solidify first, and shrinkage is sure to occur in the lower flange *A*, hence the "blind" or "lump" riser on the lower flange to feed it. The thickness of these castings is such that it was not found feasible to chill the lower flange sufficiently to cause it to solidify before the neck between the flanges.

The castings shown in Fig. 10, when poured at *D* without top risers on the flanges *A*, naturally showed shrinkage at *A*, when poured through quadruple gate at *C* they cracked near the

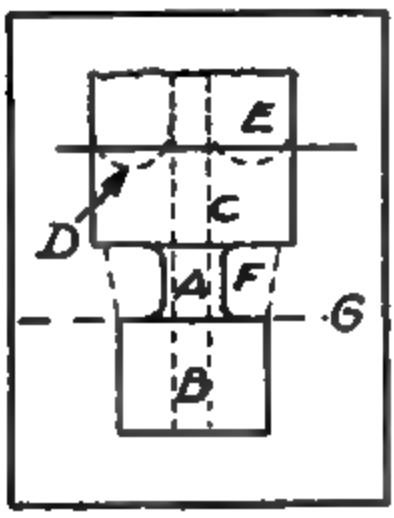


FIG. 16—DOUBLE-DRIVE PINION BLANK. FIG. 17—THESE CASTINGS INVOLVE SHRINKAGE PROBLEMS

of discard greatly reduced, although chills had to be used in the two end bosses *A*.

The author wishes to disclaim all responsibility for the excessive and incorrect gating exhibited in Fig. 13, and the poor practice, in his opinion, of stacking such small work as this, thus making a bad matter worse.

A double-drive pinion blank, Fig. 16, is a casting that can be given a great deal of interesting study, both from the standpoint of quality and workmanship, as well as from the standpoint of shop costs. If cast on end as shown, it is a three-part job, the pattern having been parted at *G*, but molded in this way, satisfactory production is not possible. Even when cast in the position shown, the lightening recess desired by customer, as shown in dotted lines *B*, is in the way of placing either a cylindrical or annular riser. The customer objected to the filling in of this lightening recess although it amounted to only 4 or 5 per cent of the weight of the casting. If cast from a split pattern on its side, two risers on cylindrical surfaces would be necessary, and any dirt or shrinkage would occur in the outside diameter where the teeth are cut. Such risers are very expensive to remove. The author personally made up five accurate estimates of the exact cost to produce these blanks cast in five different ways, and found that the best and surest, as well as the cheapest, was to cast them in the position shown, with an annular riser *E* and with the addition of metal indicated by the dotted lines at *F*. This made it a job that could be

nicely placed on a molding machine for economic quantity production, all portions of the casting would be perfectly fed, the castings would be free from floating slag or sand, and the excess metal *F* and the lightening panels *D* could be rough turned out by the foundry before shipment at a lower cost than if made in any other way. Without the addition of the extra metal *F* the lower portion *B* would not be solid unless severely chilled or unless fed with a lump riser which was objectionable for reasons heretofore explained. It is not possible within the scope of this paper to go into shop costs, but this casting is a striking illustration of the value and economy of careful and critical analysis of all production jobs, not only with a view of getting the best work, but to getting such results at the minimum cost.

Dealing With the Shrinkage Problem

The gear blanks, Fig. 17, show examples of some rather troublesome shrinkage to overcome by correct feeding. When the teeth were cut in these castings, shrink holes were uncovered at the base of the teeth opposite the intersections of the web and the rim. These shrink holes are shown at *B* in the casting which has had the teeth cut, and at *A* in the casting at the top which was rough turned for examination. These shrink holes also are indicated in the section, Fig. 18, at *B*. To eliminate these shrink holes by six risers at the intersections referred to would be at the expense of an excessive amount of top scrap, and would cause the castings to crack. To cast them on edge with one riser on the outside diameter, would not feed the portions referred to; to cast them on the side with three risers would not feed the three intervening portions or intersections; and to chill these portions was not found desirable. These shrinkage holes were prevented by increasing the thickness of the rim of the pattern as shown by the dotted lines at *C*. Fig. 18, the castings being poured on their sides with three risers and without chills. This added metal resulted in a sufficient retardation of the solidification of the rim so that the web at the six points of intersection would be fed from the rim. The rim thus remained fluid longer, drawing feed from the three risers to all portions. To check up the correctness of our

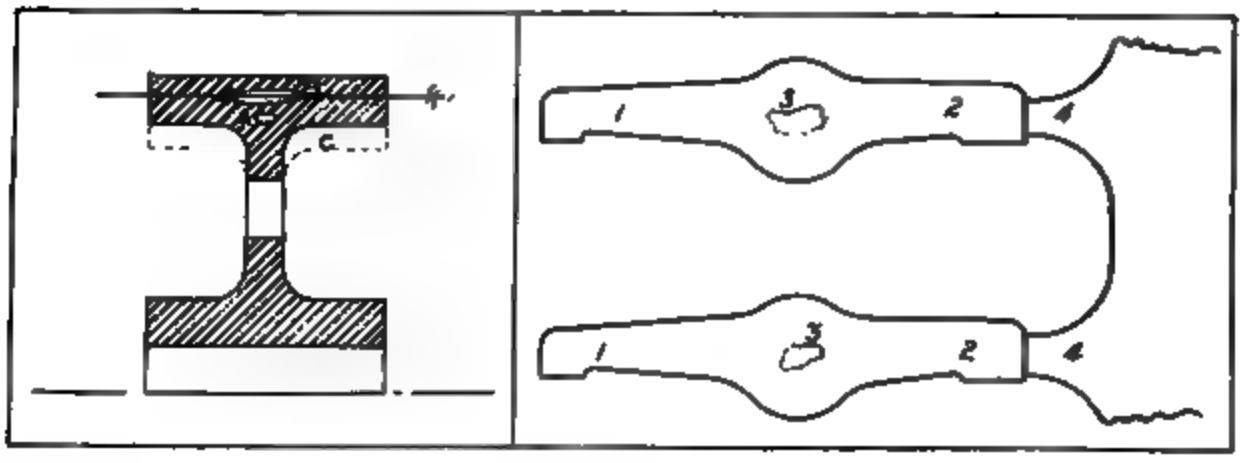


FIG. 18- SECTION SHOWING SHRINKAGE CAVITIES IN GEAR BLANKS. FIG. 19 ROCKER ARM CASTINGS WHICH SHOWED SHRINKAGE AT 3 WHEN GATED AT 4, 4

assumption, the casting to the right in Fig. 17 was rough turned to ¼-inch below the base of each tooth, and all shrinkage had disappeared except the one very small hole shown at *C* to the right in Fig. 17. This hole has been indicated at *A* in Fig. 18. The effect of thickening the rim as indicated at *C*, Fig. 18, was to materially retard its solidification, and if shrinkage appears at all, it will be very much reduced in size as shown at *A*, and it will appear below the finished line *F* where it can do no harm.

Fig. 20 shows the method finally adopted and probably the most successful one of making large and small crank pin boxes with annular risers *B*. These castings are difficult to make and

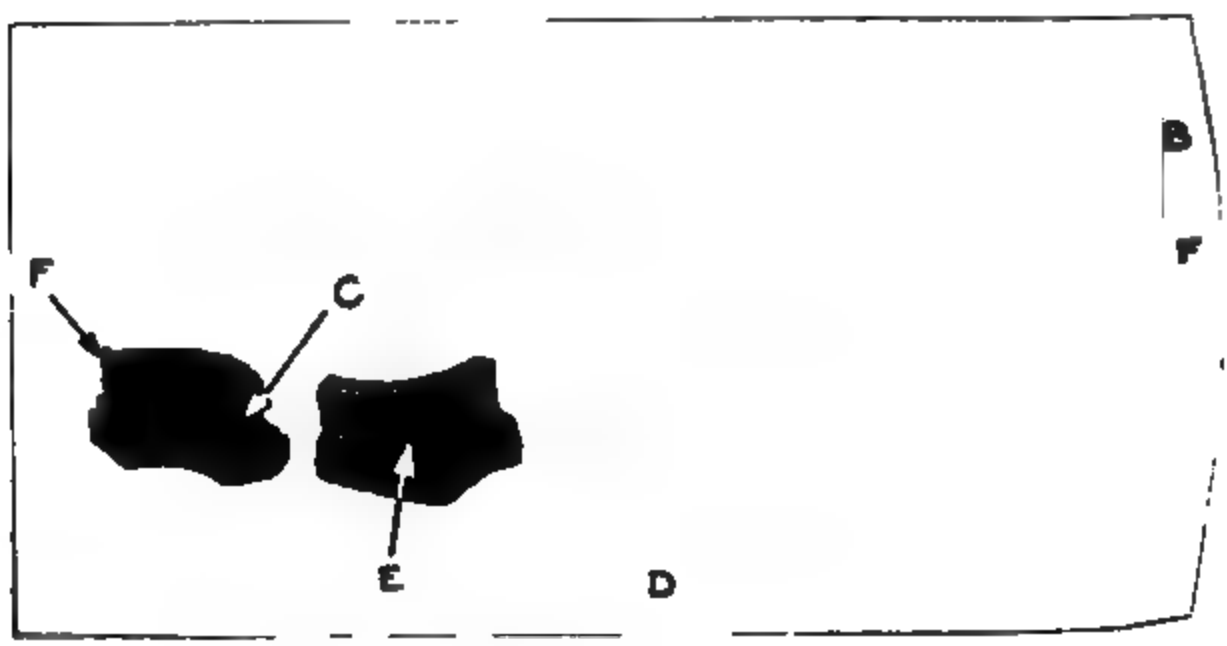


FIG. 20 GATING SMALL CRANK PIN BOXES

feed on account of the four heavy sections, *A*, in the triangle formed between the bore of the casting and the square exterior outlines. The castings are machined all over and then are sliced into halves and drilled through the haunches for the necessary bolts to bolt them around the crank pins. The drilling is the last operation, and if shrinkage holes occur at these thick corners, they will not be discovered until after the several very expensive machining operations have been completed. If even small shrinkage holes are found, the castings will be rejected. By casting them with an annular riser *B* and by chilling them with heavy nails in the four corners as indicated at *E*, the castings were found to be perfectly solid when cut open, as shown in Fig. 20 at *D*. When the annular riser was only made the thickness of the casting, shrinkage occurred at *C* below the finished lines *F;* therefore it was necessary to make the riser about ¾-inch thicker than the hub of the casting, that is, ⅜-inch thicker on each side. When made in this way these castings have been found to be free from defects which would cause rejection, and the shrinkage which was certain to occur at the four thick corners has been eliminated.

The small gated rocker arm castings, Figs. 19 and 21, when gated at *4-4*, showed shrinkage at *3*, the different sections of the castings solidifying in the order of the figures, namely, *1* first, *2* next, *3* last. In this way the thick central section *3*, possessed shrinkage holes because there was no source of feed. By gating these castings to the thick central portions as shown in Fig. 21, with gates sufficiently heavy to provide feed, the order of solidification would be *1-1*, *2* and *3*, the order desired.

Thick and Thin Sections Adjacent

Fig. 22 is a striking example of thin and thick sections adjacent to each other. The castings must be thoroughly fed or well chilled to get them solid. If risers are put on three of the teeth or thick sections of this coupling box, there are sure to be internal shrink holes in the other three thick sections which are shut off from the source of feed by the previous solidification of the sections between them. This was proved by severely chilling the thick sections between the three risers when this shrinkage was overcome, and the weight of these castings

was actually increased about 2 per cent. These castings had previously been failing, and an examination of the fractures under the microscope showed that they had been poorly annealed if at all, and physical test bars cut from the same point showed very poor ductility. These castings have since been made of lower carbon and given the double water treatment, and have proven to be extremely tough and very satisfactory.

Figs. 23 and 24 show sawed up sections of two pintle bearing castings for 3-inch field mounts made in large quantities for the ordnance department of the United States army

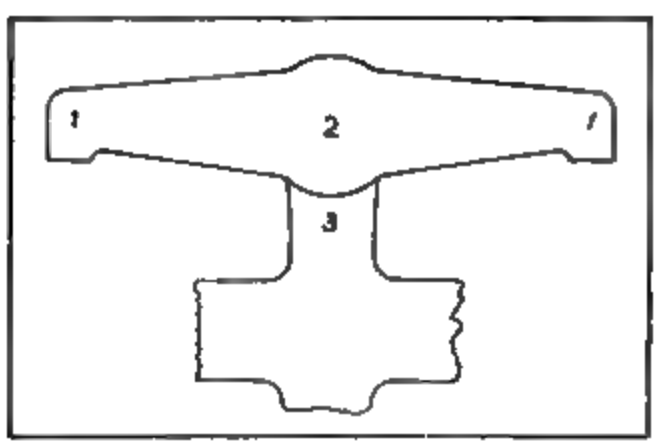


FIG. 21 THE METAL SOLIDIFIES AT *1, 1,* THEN *2* AND FINALLY *3*
FIG. 22 A CASTING WITH THICK AND THIN SECTIONS ADJACENT

during the war. Fig. 23 shows bad shrinkage below the risers *1,1* when the bearing cores were made as shown in this illustration. The risers were too small, and the choke points *BB* between them and the thick section at the end of the bearing cores solidified first; hence the thick sections below *BB* possessed shrink holes. By decreasing the depth of the bearing cores and by chamfering off the corners of same and increasing the size of the risers, solid castings were obtained as shown in Fig. 24. The evolution of these castings from the standpoint of pouring, gating and feeding was interesting, the various methods being checked up by cutting open the castings and subjecting them to other tests to make sure that they were sound and satisfactory beyond any doubt.

A complete history of the successful development of these castings would make a very interesting, instructive and valuable treatise in itself for the guidance of steel foundrymen engaged in this class of work. The writer believes that this example

inch, 90,000 pounds; elastic limit, 55,000 pounds; per cent elongation in 2 inches, 15; per cent contraction in area, 25. It was then thought by those in conference that these specifications, which are really more severe than the standard specifications for steel forgings No. 3 of the ordnance department could only be met in castings by the use of chrome and vanadium as alloying elements. An analysis was suggested, and production of these castings was begun at the Watertown arsenal foundry, steel being poured from a 2½-ton converter, using chrome and vanadium. Fifty to 75 castings made of chrome-vanadium converter steel were given various heat treatments, but invariably failed to meet the physical specifications, nor did they pass the surface inspection of the ordnance department inspectors. After considerable study and experimental work, using various compositions and treatments, the use of chrome and vanadium was abandoned and the castings were made of plain 0.28 to 0.35-carbon steel in a tilting 15-ton acid open-hearth furnace, and given a water quench and drawn. The castings thus treated easily met the specifications and hundreds were made to meet all requirements. Subsequently they were made with even better success from electric furnace steel in the new furnaces of the arsenal with very few rejections. It was through the use of the water quench and draw treatment that these important castings were successfully produced in large quantities to replace the very much more expensive forgings without the use of the expensive alloys.

This development carried on at the Watertown arsenal in connection with these particular castings finally resulted in overcoming the objection of the ordnance department to the use of water in quenching steel castings—an objection which prior to that time had been apparently irremovable.

Tests of Water Treated Castings

The writer wishes also to state in this connection that the monumental work in the development of the water treatment for steel castings originally done 14 or 15 years ago by Dr. H. M. Howe and John Howe Hall, at High Bridge, N. J., was used absolutely as our basis and guide by those of us in charge of this work at the Watertown arsenal in accomplishing these re-

sults. As a matter of interest and reference, the following actual tests on these heat treated castings will be of interest in comparison with standard specifications for castings and forgings. The tests given are characteristic of those obtained right along, day after day, on numerous heats of open-hearth and electric steel poured into these castings at the arsenal:

Physical Properties

	Standard Specifications			
	Castings		Forgings	
	A. S. T. M. Hard	U. S. Ordnance, No. 3	A. S. T. M. Anneal'd	Ordnance No. 3-FS
Tensile strength.....	85,000	80,000	80,000	90,000
Elastic limit	38,250	36,000	40,000	42,000
Per cent elongation in 2 inches	15.0	15.0	22.0	16.0
Per cent contraction in 2 inches	20.0	20.0	30.0	24.0

Actual Tests Unalloyed Steel Castings—Heat Treated

Tensile strength.....	106,350	100,000	97,500	93,500	92,000	98,500
Elastic limit.....	70,600	64,300	58,200	52,500	57,000	60,000
Per cent elongation..	19.0	20.0	21.0	24.5	24.0	16.0
Per cent contraction.	30.7	34.0	32.1	43.3	37.2	27.4

The author hopes that by a study of these sample cases and their analysis in the light of the rules he has endeavored to lay down, some foundrymen may be enabled to see their besetting problems a little more clearly and to encompass their solution more fully. If so, his efforts in preparing this paper will not have been wholly in vain.

Discussion—Pouring, Gating and Feeding Steel Castings

The Chairman, R. A. BULL.—I would like to ask Mr. Farquhar if he has made any experiments to determine the amount of benefit derived by holding the ladle a given time after being tapped from the furnace.

MR. R. B. FARQUHAR.—That will depend upon what kind of steel you are making. There is a decided and tremendous benefit in holding the ladle in the manufacture of converter steel—to a greater extent, I believe, than in either the electric or the open hearth process. It gives the gases time to float off and work off. The amount of time for holding depends on the size of the casting you are going to pour. To some extent, of course, there are other metallurgical advantages, depending on where you apply your ferroalloys, what your initial temperature is, and whether that temperature is too high or not. There are a good many factors that enter into it. There are some shops where you have a considerable distance to transfer the metal, and the ladle gets held long enough anyhow in the natural transfer. The proper procedure depends a great deal on the conditions that you are trying to accomplish.

The Chairman, R. A. BULL.—What do you favor in the case of electric steel in the ordinary class of work?

MR. R. B. FARQUHAR.—If you are going to pour large castings and the metal comes out of the furnace hotter than you want it, hold it. If you are going to pour small castings, and have, as we often have, a whole side floor that has to be poured with the ladle before it gets too cold, you want to pour it just as quickly as you can.

The Chairman, R. A. BULL.—Have you made any tests as to determining the beneficial effect on the metal itself in the electric steel?

MR. R. B. FARQUHAR.—I have not, as far as its effect on the physical test is concerned, for example, or the purity of the metal. The advocates of the various processes have their views and there would no doubt be advantages to holding electric steel similar to the advantages of holding converter steel but perhaps not to the same degree. I don't want to lead into any argument on the merits of each, because there is no question but that the best steel can be made in all three processes. While the electric process does not subject the metal to that forced draft of air which finally divides all the particles of slag in it, as it does in the converter process, yet in tapping the electric furnace you will get a certain amount of slag churned up through the bath anyhow, and there would no doubt be an advantage in holding it a certain length of time to let it float off.

MR. S. STONEHAM.—Assuming we had a mold to pour that weighed, say six tons, and with a two-ton converter, we had to take three blows to pour it, what would happen to the metal in holding it?

MR. R. B. FARQUHAR.— We would have to hold the first ladle about 40 minutes. I would say that would be feasible in a two and one-half ton converter. I have seen converter metal held 30 minutes. I don't know that I have ever seen any held 40 minutes. I have seen 25-ton ladles held two hours frequently in iron, and in pouring very large ingot molds, which I had to do at one time, we used to hold the 25-ton ladles two to three hours at times. We covered them with charcoal and made a pipe spray to keep the charcoal hot. Perhaps something like that might be done on the first ladle when a two and one-half ton converter is first blown out.

MR. S. STONEHAM.—Wouldn't you be afraid of getting the charcoal mixed up with the carbon?

MR. R. B. FARQUHAR.—Yes, I wouldn't advocate charcoal.

Obtaining Molding Materials for the Steel Foundry

By R. L. Lindstrom, Montreal, Can.

Obtaining the highest quality of materials commensurate with the purpose for which they are required, is conceded to be good practice by manufacturers who must strive for both quality and production. This practice generally results in a lower ultimate cost, which is especially true in the purchase of molding materials on which the cost of freight is sometimes as great or greater than the cost of the material purchased.

Apparently there has been but little work done in developing standards or specifications by which these materials may be purchased, the most reliable guide having been the results obtained in shop practice. It is quite difficult for steel foundries which use several thousand tons of sand and clay each month in the preparation of facing sand mixtures, to ascertain the real results of running in a carload or two of an untried sand or clay, and they are generally reluctant in trying a larger quantity because of the danger of spoiling the sand heap with unsatisfactory material before the results of using the new material can be determined.

It was to overcome this difficulty that a study of these materials was made in the laboratory and the results obtained have given a good idea in advance of what will be the results in the shop. The primary idea was to keep all tests as comparable with shop practice as possible, and, due largely to this, we have never judged a clay or sand but what shop practice has borne out the laboratory results.

Clay in Steel Molding Sand Mixtures

Plastic fireclays are used extensively in sand mixtures for molds for steel castings, especially for green-sand mold making. The object of the clay is to act as a bonding material

for the highly refractory silica sand. It is folly to buy a high grade sand and mix this with a clay which is low in bonding power, which necessitates the use of such a high percentage of clay that the voids between the sand grains are filled and the natural vent is destroyed. This is certainly one of the reasons for poor finish on castings. It is also poor practice to buy a clay having a low softening point in order to obtain great plasticity or bonding power, for even though this will allow a lower percentage of clay to be used, it is liable to bake to a hard mass at pouring temperatures, causing high sand loss and extra cleaning room costs.

The ideal clay is one having both high bonding power, so that the smallest possible amount can be used, and a high softening point. It is sometimes difficult to find clays having both these valuable properties, but the appearance of the castings, ease of cleaning, etc., justify the effort.

Methods of Testing

The first test made on clay was on the bonding power, and as this varies with the moisture content, the pressure applied in mixing with the sand, kind of sand, etc., the following practice was followed:

Dry Ottawa, Ill., sand is used as a base for all tests as this was found to vary but little in fineness. Seven hundred grams of this sand is thoroughly mixed with 70 grams of the sample by rolling together on glazed paper. Sufficient water (25 cubic centimeters is generally required) is then added so that the mixture will just adhere to the palm of the hand. This is then kneaded for exactly two minutes in the same manner as pat tests are made in a cement testing laboratory. It is then allowed to stand for 12 hours in a covered receptacle, in order to develop its maximum bond. It is found by actual test that the bond increases considerably in 12 hours but that after this period of time the increase is very slight.

The object of using 10 per cent of clay and kneading for two minutes is to obtain a bond which is comparable with that of the same mixture run in the pan mill for two minutes, but only having 5 per cent clay.

The mixture is then placed in the core box shown in Fig.

consumption over 50 per cent of what was used before testing was started, and obtained a much nicer finish on the castings with less labor in the cleaning room.

Table I is a list of some of the clays tested showing the softening points and bond tests of clays from various sources. This shows a range of result too great to allow indiscriminate purchasing, if best results are expected from the foundry.

Table I.

Clay	State	Plasticity Per cent	Melting Point Degrees Fahr.
1	New Jersey	119	3090
2	Pennsylvania	108	2730
3	New Jersey	106	3030
4	Missouri	100	3182
5	New Jersey	100	2950
6	Ohio	92	2790
7	Missouri	92	3040
8	Pennsylvania	92	2890
9	Pennsylvania	92	3020
10	Missouri	92	3020
11	Ohio	92	2820
12	Ohio	90	2760
13	Pennsylvania	85	2760
14	Virginia	84	3020
15		79	3040
16	Ohio	84	
17	Ohio	82	
18	Ohio	80	
19	Pennsylvania	79	
20	Indiana	78	
21	Pennsylvania	77	
22	Pennsylvania	75	
23	Ohio	73	
24	Pennsylvania	71	
25		70	
26	Pennsylvania	60	
27	Ohio	67	
28	Ohio	67	
29	Pennsylvania	Very Poor	
30	Ohio	Very Poor	

Fineness of clay is very important for foundry work, as a much stronger, smoother facing will almost invariably be obtained with a very fine clay. It is quite difficult to break up large particles of clay in the milling machine, and they generally flatten out and have a tendency to scab the casting.

A specification for foundry clay could perhaps be worked up along the following lines:

Table II

No.	State	Mesh..	Fineness 20	40	60	80	100	100X	Total on 60 mesh	Silica content
1	Illinois	....	10.75	33.6	44 0z	.37	2.41	5.62	88.34	97.25
2	Pennsylvania	..	8.00	81.0	7.5	1.5	.5	1 5	90.5	97.25
3	Ohio	.....	19.0	29.0	33.0	14.0	2.5	2.5	81.0	97.40
4	Ohio	.....	28.2	51.8	12.2	3.4	0	2 5	93.2	96.52
5	New Jersey	..	11.0	17 4	25.6	19.9	10.2	15 0	51 9	97.00
6	Ontario	....	2.4	62 8	26 4	6.9	7	.8	91.6	98.97
7	Quebec	....	1.6	25.8	33.1	27.4	5.6	6.5	61.5	97.70

Sand No. 2 which has 81 per cent remaining on a 40-inch screen was found to have the best venting properties. This sand also has the highest total percentage remaining on a 60-mesh screen.

An ideal size of sand grain for average green sand molding would be 100 per cent on a 40-mesh screen, but as this

FIG. 7C—NO. 7 SAND, SHOWING ANGULAR PARTICLES

is impossible, we have adopted the standard of 85 per cent for the 20, 40 and 60 mesh-screens This gives a fairly good field to pick from of those sands having reasonably good venting properties.

The study of sands under the microscope is very interesting, and a good idea of the quality of the material can be obtained in this way. The illustrations shown here were taken primarily to show the shape of the grains.

Sand No. 1 is shown in Figs. 1-A, 1-B, 1-C and 1-D, showing the 40, 60, 80 and 100 mesh respectively Even the finest grains are well rounded. Fig. 1-E shows a single grain of the

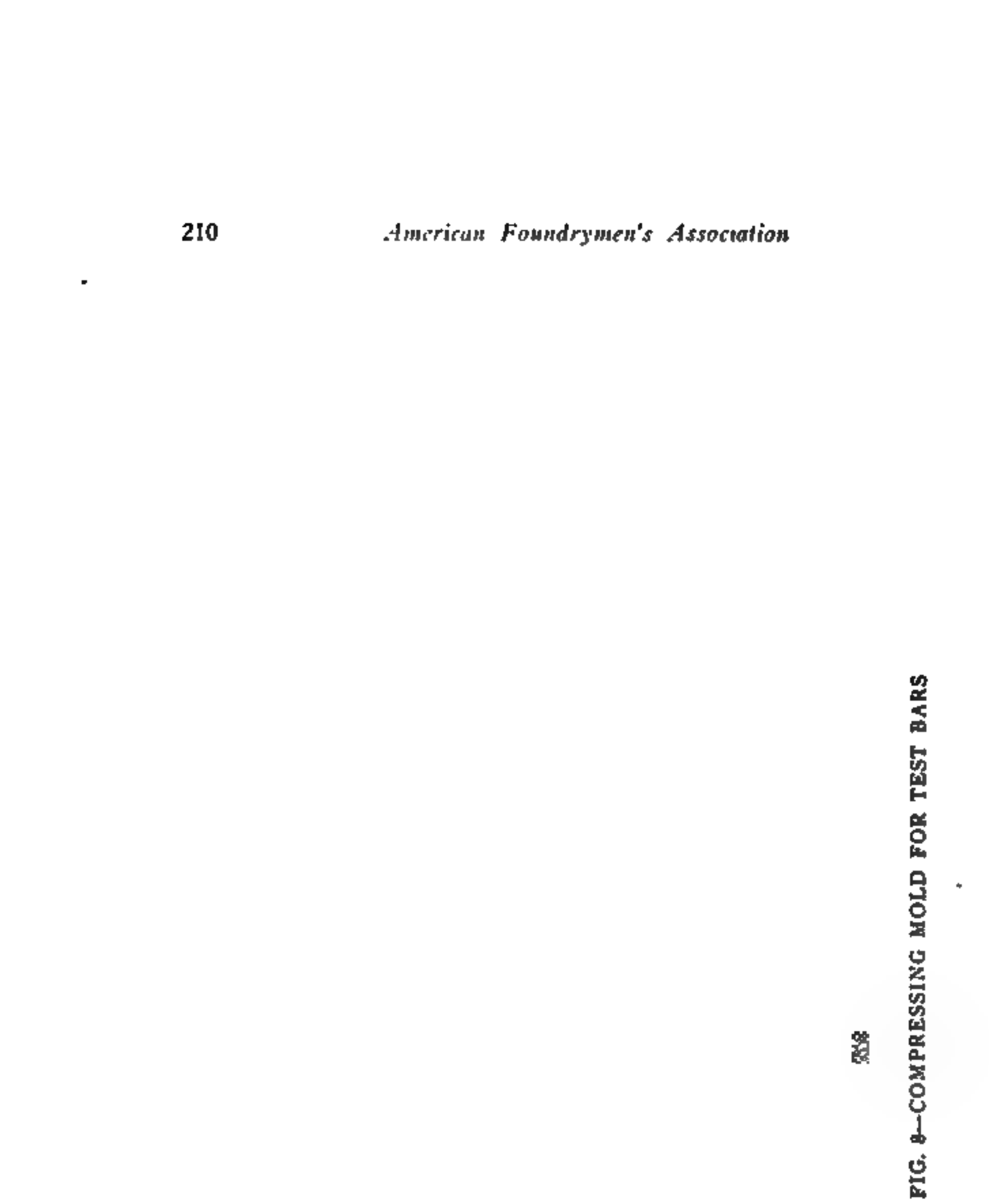


FIG. 4—COMPRESSING MOLD FOR TEST BARS

same sand more highly magnified, the idea being to show more clearly the details of the grain. This sand is used quite extensively.

Sand No. 2 is shown in Figs. 2-A and 2-B. This is not as well rounded as No. 1 but is used very successfully, perhaps because of its great uniformity.

Sand No. 3 is shown in Fig. 3. The main difference between this and No. 2 is the screen test. If this sand was properly screened it would perhaps be as popular as No. 2.

Sand No. 4 is shown in Figs. 4-A and 4-B. The grains are well rounded and uniform in size. This sand is used extensively, especially by the advocates of coarse sand.

Sand No. 5 is shown in Figs. 5-A and 5-B. The shape of the grains is good; they have particles of fine sand adhering to them. This is also successfully used.

Sand No. 6 is shown in Figs. 6-A and 6-B, and is being used successfully in an experimental way.

Why Certain Sands Are Unsatisfactory

Sand No. 7 is shown in Figs. 7-A, 7-B and 7-C. This group is interesting, due to the fact that the sand is not fit for foundry use and the pictures evidently show the reason why. Several hundred tons of this sand were used, during a shortage of our regular sand, and the results in the shop were anything but satisfactory. The grains are not rounded, but angular, and split quite readily into smaller angular particles, as shown in Fig. 7-C. It packs together into nearly a solid mass when rammed, leaving little or no vent, and consequently the steel will not lay quietly upon it.

This may be the reason why there are so many silica sands which are not suitable for steel foundry work.

This paper is not written with any intention of making definite statements as to what causes certain sands and clays to be suitable while others of the same analysis are not so satisfactory, but merely to show how these simple tests have been applied by us as a guide in selecting this class of material.

It would seem to me that there is a great field for real

Discussion—Molding Sand

A MEMBER.—As I understand it, the rounded grains of sand are more apt to give a smooth casting than the angular grains or the split grains.

MR. R. L. LINDSTROM.—It has been our experience that the rounded grains of sand seemed to be individual crystals and they will not split up into dust. In ramming together they still leave vent, leave voids between the grains of sand. We made venting tests by forcing a certain volume of air through certain amounts of sand, rammed at a certain pressure. We did not finish those tests, but we showed clearly that we could send a larger volume of air, during the same period of time, through a block of sand of rounded grains rammed at a certain pressure, than we could through a block of sand of angular grains. The angular grains seemed to leave no voids.

MR. A. W. GREGG.—I would like to ask if you have any tests that give you an indication of how sand can be used a second time. We find in our foundry that with some sands, you can use a large proportion of old sand.

MR. R. L. LINDSTROM.—I don't think that is the sand. I was going to go after that problem along the line of clays, not sand. I cannot see why the sand should deteriorate if sand crystals do not break up by heating, and if they do fuse by heating. If they do fuse or become unfit for use, I would rather think it is due to the quality of the clay. In other words, I like to regard clay in the green sand facing as an impurity, and the less of it you have to use the longer your packing sand would be good to use as facing.

The Chairman, R. A. BULL.—Do I understand you find it to be the characteristic of one or a few sands to crack and break off under the application of heat, as opposed to the general tendency of other sand?

MR. R. L. LINDSTROM.—Yes, it not only did that in the laboratory, but it also seemed to do it out in the shop.

The Chairman, R. A. BULL.—Do you find any relation between the silica content and the fusibility of clays?

MR. R. L. LINDSTROM.—Strange to say we didn't, so in order to corroborate my melting point results I sent them to a university in Montreal and had them tested and the results obtained there were the same that I got before. I used to think that an ideal clay had 55 per cent of silica in it, but one clay mentioned in the paper has 63 per cent of silica and has a very high melting point.

MR. R. J. BAUER.—What would be the result of the test if the clay contained 85 per cent silica? Would it be an advantage or a disadvantage?

MR. R. L. LINDSTROM.—I don't know. The clay as I understand it, is an aluminum silicate, and it would not be all clay if the proportions were that high. Now theoretically, and what I have read about clays, the higher the silica goes after you get the theoretical combination in which you would have 55 per cent of clay, the lower the melting point. With the 85 per cent I don't know what would happen. The 63 per cent was a surprise to me, because of the higher melting point.

I am commencing to believe right now that the higher the silica in a clay when you are mixing with pure silica, the better your mixture will be. I have not been able to prove it, but if your clay has 85 per cent of silica, and still has a good bond, you don't have to use an unreasonable quantity of it, I would say it should be very good for g

MR. R. J. DOTY.—I would like plasticity rating which he gives m a number of results in each case you found on your arbitrary scale

MR. R. L. LINDSTROM.—We about 18 inches square and we m and made several of these bars 12 them over the edge of the plate and taking the average length. U got three good broken pieces off bars that gave us 12 pieces t of those, the length of pie we obtained these res of the plate as lo over the edge

Making Acid Electric Steel

By James W. Galvin and Charles N. Ring, Springfield, O.

In the manufacture of steel one of the most difficult problems to be dealt with is the oxidation of the metal that takes place during the process of melting down and refining. Regardless of what process is used, this matter of oxidation must be taken into consideration and even in the crucible process oxidation cannot be entirely eliminated, as there is always a certain amount of oxygen present in the charge in the form of rust or oxide of iron and also in the atmosphere contained within the pots. In fact, it is very doubtful if there is a possibility of making steel, by any process, in which a certain amount of oxidation of the metal does not take place.

The birth of the electric steel furnace is due to the desire to produce a steel by a process wherein this oxidation is eliminated or reduced to a minimum. After years of hard work and patient study the electric steel furnace has been developed to a point where it is a commercial success and has been heralded by the manufacturers of these furnaces as the ideal method by which to make steel. The claims made for these furnaces are, among others, that it is the one method by which the oxidation of the metal can be eliminated or at least reduced to a minimum, being superior in this respect to the old crucible process; that it requires less expert operators to produce the metal; and that the product is superior to that of any other process. There are many advantages to the electric steel furnace in certain lines of work that are admitted by all familiar with the steel industry, but whether or not we have thus reached perfection remains to be demonstrated.

Developed by Electrical Engineers

Up until the last few years the electric furnace has been developed entirely by electrical engineers and attention paid largely to the electrical features for the purpose of developing the high amount of current necessary and bringing the cost

of operation within practical limits. This one sided and the unfamiliarity of the engineers and manufacturer these furnaces with metallurgical operations involved j ably has been the reason that they have advertised that skilled men could operate these furnaces as successfull those skilled in the metallurgy of steel. This has been of the gravest mistakes connected with the developmen the electric furnace in commercial practice. More compl and faults, due to the ignorance and inability of the have been registered against the electric furnace than any other cause. Without doubt it takes as skilled if n more highly skilled man to operate an electric furnace as it for any of the other processes. The sooner the furnace m facturers realize this fact the better it will be for business.

In dealing with the electric steel furnace as the ag of production in steel foundry practice the acid furnace will be considered. The method of building up and se the furnace bottom is of prime importance to the life of furnace and also to the speed in melting down the charge bringing it up to temperature. To insure a hard, lasting bo it should be burned in layer by layer so that the sand is se the way through and is not merely glazed over the top wi soft spongy interior that will rapidly eat away as soon as surface is cut into.

Bottom Should Have Steep Sides

This bottom also should be so built that when fini it will be cup shaped rather than saucer shaped. In c words the bottom should be rather deep with steep sides stead of ones gradually sloping up to the side walls of furnace. In building this bottom up to the side walls should be taken that no ledge is left at the point where bottom meets the side walls. There are several advant to this construction. A bottom of this type permits charging of a greater tonnage per heat in a furnace of g area and insures the lodgment of the material charged r directly under the electrodes than in a furnace where bottom is more flat or saucer shaped.

When the heat is melted down on a bottom of this type there is no unmelted material (sometimes called a bear) left hanging to the side walls, which must be pulled loose and into the bath in order to be melted up. Where the side walls are steep as described this material will of its own weight tear loose from the sides and slide into the bath. The precaution in not leaving any ledge at the junction of the bottom and side walls is to eliminate any chance of some of the material charged to lodge there and fail to slide into the bath and so delay the furnace while the operators reach in with a bar or hook and drag it down into the bath. In having the charge thus placed more directly under the electrodes instead of being scattered about over a greater area, greater melting efficiency is obtained from the current used because a greater percentage of the total charge is subjected to the direct flow of the current and is rapidly melted by reason of the great heat generated from the internal resistance of the metal to the flow of the current. Where the charge is scattered out only a small percentage is subjected to the internal resistance and the balance must be melted by radiated heat from the arc or heat conducted from the center of the charge outward to the sides. This radiated and conducted heat is not nearly as high in temperature as the heat generated by internal resistance and a large part of it is lost by radiation from the furnace and to the roof of the furnace. The greater the proportion of the charge that can be subjected to the direct flow of the current the faster will be the melt and the greater proportion that must be melted by radiation and conductivity the slower will be the melt.

Sand Lining on Back Wall

In building up a bottom of this type it also is advisable to run the sand up on the back wall above the tapping hole as high as possible. It is the practice at the Springfield plant of the Ohio Steel Foundry Co. to run this sand up nearly to the roof of the furnace. This is rather difficult to do but by taking a little time after each tap and building up gradually from just below the level of the tapping hole it finally can be accomplished. The purpose of this built-up

back wall is twofold. In tilting over the furnace to tap out a heat the slag in the metal will rise considerably above the level of the tap hole and will have a very severe effect of erosion or cutting into the back wall. By having the silica brick in the back wall thus protected by a heavy layer of sand which can be replaced after each tap, the brick themselves are saved from being cut and the life of the back wall is considerably prolonged. In tapping out a heat the furnace can be partially tilted over to bring the slag above the tap hole before the hole is completely dug out. Thus, when the hole is later dug out, the metal will precede the slag, providing a slag covering in the ladle without causing the violent intermixture which occurs when the slag comes out with the steel. Another advantage to this high back wall lining is that a larger heat can be charged by the simple expedient of tilting the furnace backward slightly from the perpendicular and letting the metal rest against this heavy lining as it melts. When the whole charge is melted, the furnace can be turned back to the perpendicular without danger of the metal running out the charging door.

Scrap Should Make Compact Charge

Much time and cost of electrical current can also be saved by using scrap that is in such physical shape that it forms a compact mass instead of being badly interlaced with large open spaces between the different pieces. A compact charge of this kind offers a more continuous path for current from the electrodes. Where the charge has large open spaces the current is compelled to jump across these open spaces. This entails a reduction in efficiency as a certain amount of heat is lost by radiation, from each jump of the current from one piece to another. Each one of these jumps also reduces the percentage of total current used that could be utilized with greater efficiency by direct passage creating the intense heat due to the internal resistance of the metal. Another factor to be considered is the fluctuation in the load that the power plant is compelled to carry where the charge is not in compact form. In loosely piled charges, the contact does not remain constant but is contin-

ually making and breaking, due to the fact that no continuous passage is furnished and as different pieces of the charge are melted they fall away from the electrodes breaking the contact. The electrodes will automatically adjust themselves o form a new contact. Each one of these makes and breaks uses a loss of time and creates a high momentary demand n the power station.

Scrap of a nature to form this compact mass is not always ailable and when such is the case the following scheme can adopted. When charging the first heat for a day's run e more metal than you intend to tap off. When the first at is tapped a certain amount of liquid metal will be left the furnace into which the new charge can be thrown quickly as possible. This will result in the whole mass ing welded into a solid compact mass that offers a continu- s passage for the current. This operation can be con- ued for a day's run with repairs being made to the side lls of the furnace while the heats are being charged. The ttom of the furnace will very nicely stand a day's run with- t being repaired by additions of sand. After the day's n has been made and the furnace drained out on the last the bottom of the furnace and the side walls can be ry thoroughly repaired and made up for the next day's n. In making this additional charge, care should be taken at as much of the slag is drained off from the previous at as possible and if any amount of slag is left a small antity of fine ore should be added to thin up the slag ich has become viscous, otherwise the charge will ride on p of the slag and not thoroughly mix with the metal under- ath.

Slag Acts as Insulator

It naturally would be supposed that after a heat has een melted down and all becomes a liquid mass the ideal ondition for the free and steady passage of the current has been attained. This would be the case were it not for the formation of the slag on top of the metal that now takes place. As it becomes heavy and thick this slag acts as an insulator to the passage of the current from the electrodes to the metal

beneath the slag. In an effort to make contact the electrodes automatically lower themselves and bury their tip in the slag. This adds greatly to the electrode consumption and increases the carbon content of the bath. To eliminate this difficulty it is advisable to add a small amount of fine iron ore to the slag from time to time to thin it up and then to drain it off through the charging door as necessary to keep the amount down to proper limits for good metallurgical operation and also so as not to interfere with contact sufficient to draw the electrodes into the slag.

Another feature to be considered in the speed of melting is the length of the arc from the electrodes. The longer the arc drawn the more it spreads out before striking the metal and the greater the radiation of heat from this arc. This radiated heat is relatively low in melting efficiency and proportionately harder on the roof and side walls of the furnace. The length of this arc can be controlled by proper manipulation of the switchboard.

Controlling Silicon Content

One of the most difficult operations connected with the acid electric furnace is the control of the silicon content of the finished product. This fluctuation of silicon content is primarily due to the high temperatures attained in the electric furnace and the reversal of certain chemical affinities due to this intense heat. In the temperature usually attained in the open hearth, the carbon in the original charge is oxidized off by the reason of the oxidizing nature of the flame and by the addition of an oxidizer in the form of iron ore. At this temperature carbon has a greater affinity for oxygen than iron has and so will rob the iron ore of its oxygen and pass off in the form of carbon monoxide and carbon dioxide. The sand from which the bottom is made is chemically known as silica and is composed of silicon and oxygen. In the temperature of the open-hearth process the silicon in the sand has a greater affinity for oxygen than has carbon and therefore is not robbed of its oxygen by the carbon. But in the temperature of the electric furnace carbon has a greater affinity for oxygen than has silica and so if not prevented will take the oxygen from the silica sand

and leave the silicon. This will be absorbed by the metal and thus raise its silicon content. It also is probable that the iron has a reducing effect on the silica sand and silica in the slag, robbing the silica of its silicon, forming silicate of iron and leaving free oxygen. As stated this peculiar condition is due to the intense heat of the electric furnace and it is thought that the proper way to avoid this trouble is to get the furnace reactions as nearly completed as possible before reaching this high temperature.

This idea is followed at the plant with which the writer is identified. As soon as a heat is melted and before the high temperature is attained in the electric furnace the carbon content is reduced to the desired per cent by adding iron ore the same as in the open hearth. The heat is shaped up at this lower temperature and then rapidly brought up to the required temperature and tapped out before further reactions can cause a rise in silicon content. By this method of operation almost complete control of the silicon content has been gained.

How Oxidation is Kept Down

The matter of oxidation of the metal in the electric furnace also is a serious factor to contend with even though the method of producing the temperature does not have an oxidizing effect. Oxidation of the metal does take place by reason of the reactions in the furnace during the process of melting down and bringing up to temperature. In order to insure sound castings care must be taken to free the metal from the oxides formed and gases evolved. There are many conflicting opinions on what reactions take place and what methods to employ to deoxide the metal. Most of these opinions are very technical and the explanation lengthy and cannot be dwelled upon here. The method employed at our plant runs along parallel with our method of silicon control. The temperature of the metal is kept down to about open-hearth temperatures and the carbon is oxidized off with small additions of iron ore so that there is at no time an excess of iron ore added above which is necessary to lower the carbon to the desired content. Sufficient manganese is charged in the initial charge to insure some residual manganese in the bath at the time the carbon has

reached the desired content and also to supply the slag with the proper amount of manganese so that when it reaches a balanced stage of basicity too much iron has not been oxidized to supply this basicity. The slag also is kept thinned up so as not to be highly oxidizing in nature and in order to allow the easy escape of gases formed beneath. When the proper chemical content is reached and the deoxidation of the metal accomplished the bath is then brought up to a very high temperature as rapidly as possible (usually from five to seven minutes) and tapped out. Additions of manganese and silicon are made in the ladle but usually little silicon is added as the residual silicon in the bath is sufficient to quiet the metal. This residual silicon is absorbed by the metal during the period it is being brought up to the high temperature required for pouring.

In speaking of deoxidizing the metal, the word is used relatively as complete deoxidation is impossible. The electric furnace permits of more thorough deoxidation than does the open hearth and thus is one more step ahead in the steel industry. However, in order that it may make its way against other methods, steps must be taken to reduce the cost of operation from a fuel standpoint. One of the most logical ways of reducing this cost is to provide better furnace insulation than is available at the present time. More rapid melting also would be advantageous as the shorter the time in melting the less the amount of radiation from the furnace per heat.

Discussion—Making Acid Electric Steel

MR. H. A. NEIL.—How do you know how much metal you are taking out of the furnace?

MR. JAMES W. GALVIN.—The amount we take out of the furnace is weighed by a ladle scale.

MR. BALDWIN.— I do not believe there is much heating in the charge, due to resistance. It is practically all due to the radiation of the heat from the arc, and I also do not think that a deep bath is a good thing. One of the functions of the electric furnace is the elimination of the slag or nonmetallic impurities. They are disseminated throughout the entire bath and the deeper the bath the longer the time required for the particles to rise and amalgamate with the slag mass.

MR. JAMES W. GALVIN.—Regarding the depth of the bath in relation to the nonmetallic inclusions not having sufficient time to rise to the top of the bath with the slag, we have taken the precaution to tap out these in the first place in order that we do not get the violent mixture of the slag and metal. After tapping out into the ladle at the high temperature we allow the metal to stand 10 minutes before tapping off into the shank ladle, and this gives it time for the sonims to coagulate and rise to the surface. We get a very clear metal so far as non-metallic inclusions are concerned.

MR. S. STONEHAM.—I would like to ask the speaker if he found any difference between the metal that is on top of the ladle and the last drop that he takes from the ladle, and also whether he finds any difference in the silicon and manganese content, and in the tensile strength of the metal?

MR. JAMES W. GALVIN.—We have run analyses on the steel from when we first poured into the ladle to the last poured into the ladle, and we find a practical uniformity in our silicon content. We have control of the silicon on the electric furnace whereby we hold the silicon between 0.20 and 0.35 per cent without fail for as high as two and three hundred heats in succession.

MR. JONES.—With the deep bath does not Mr. Galvin find that the upper layer of metal going into the ladle first is of a different composition than the residual steel in the furnace? Moreover, isn't it true that the reduction of silica by the carbon occurs from the slag in the main, rather than from the bottom or the sides of the furnace? My experience has been that the silicon in the steel is obtained mainly from a highly silicious slag and the furnace metal at a high temperature.

MR. JAMES W. GALVIN.—There was undoubtedly an oxidation in carbon during the last seven minutes. But that had to be taken into consideration. Were we tapping out for 0.15 carbon we would naturally have a little more than that when we take our preliminary test. You have to figure on the drop between the time the test is taken and the time you tap out. The oxidation is going on at all times. As I stated, when we are going through the high temperatures the reaction is taking place between the carbon and the silicon in the bottom. The carbon is partly oxidizing out by reason of the fact that it is robbing the silicon. We get the rise in silicon content during the period of heating up.

A MEMBER.—I think the increase in silicon content during the period of intense heating just before tapping is probably caused by the reduction of the silicates by your carbon electrodes. I don't think you will get much silicon from the lining; it is going to come from the silicates of the slag.

MR. F. W. BROOKE.—A great deal of stress has been laid on having the charge very compact. That might be misleading to the average melter. There is such a thing as having that charge too compact. It has always been my experience in melting that if you tried to melt say 100 per cent of boiler plate punchings, which is the scrap that all the melters try to get hold of, you would have far more difficulty and very much less thermal efficiency than if you melted down a charge which was very much lighter.

It has been suggested that the furnace manufacturers should, try to increase the insulation efficiency. That has been don-

and has been found not to be the right practice. Today in making steel castings, where a high temperature is required, we get to the point where we reach the breaking down point of the refractories and by increasing the thermal efficiency of the furnace by using high grade insulations, we break down the refractories in the furnace. To give an idea of the efficiency reached, the old crucible steel furnace has a thermal efficiency ranging from 2 to 3 per cent, and the open-hearth has a thermal efficiency of about 15 to 20 per cent. The modern electric furnace has an efficiency of 65 per cent. That means that in the days of the crucible we used to get about two out of 100 of the heat units in the furnace. Now we get 65 out of the 100 in the electric furnace.

Finally I would like to suggest that the electric furnace manufacturer is the man who has developed the electric furnace. The electric furnace has been developed in the last 12 years by leading metallurgists. The manufacturer of electric furnaces today has realized that he must carry a staff of metallurgists, and the good manufacturers do that. They carry at least three or four qualified metallurgists, and probably only one electrical engineer.

Mr. James W. Galvin.—I don't wish to say anything harsh against the manufacturers of the furnace. I simply stated what has been a fact—that the furnace manufacturers have advertised that the electric furnace is fool-proof, and that it can be operated by unskilled labor at a very low cost.

Mr. F. W. Brooke.—I would suggest that the matter of skilled labor has probably been used by electric furnace salesmen and has been used in this way: How many steel manufacturers operating an open-hearth furnace would put the furnace in the hands of an unskilled operator? He would have the roof down the second heat. How many crucible furnace operators would put it in the hands of an unskilled operator? Comparatively, the electric furnace can be handled by the unskilled man better than could either the crucible or the open hearth. There was their talking point.

Standardizing the Design and Construction of Patterns and Small Steel Castings

By K. V. Wheeler, Lebanon, Pa.

The writer would like to draw attention to some of the problems that are continually being encountered in making small steel castings, and which no doubt are applicable to the making of all steel castings, regardless of their classification as to size. A few suggestions also are offered which, it is believed, would tend to solve these problems and reduce the making of steel castings to a more positive basis, eliminating much of uncertainty and guess work, not only from foundry practice, but from the minds of consumers of castings as well.

Some of the suggestions noted have been tried with more or less success, while others are entirely of a theoretical nature. It is solely with the idea, that by the bringing of these questions to the front, discussion will be stimulated, and possible action will be taken, that this paper has been written.

Progressive Spirit Is Shown

Thanks to the industrial engineer and to the mechanic ingenuity and commercial incentive of the manufacturers of foundry equipment, the majority of foundrymen are today enjoying the benefits of modern developments in machines, plant lay-out, method of handling and routing materials, and other improvements of a similar nature. It is indeed a pitiable sight to view a foundry that fails or refuses to recognize the fact that this is a progressive age, and endeavors to operate under conditions very common a few years ago.

There is another problem, which though not so evident on the surface, is equally as essential to progress. New machines, tools, and methods of handling materials are visible assets because the foundryman can see them in operation and his records reveal their worth as compared with antiquated equip-

ment and methods. However, this second problem which has been referred to is equally far-reaching and offers as great possibilities from a standpoint of results, as the installation of good equipment. The nonappreciation of this problem has been largely responsible for many failures, including not only those of foundrymen who have gone out of business, but also those of foundrymen who have not progressed. This problem is the impracticability from a commercial foundry standpoint of a large percentage of the patterns submitted to steel foundrymen for producing castings.

Standardization is Needed

The foundry industry has no one but itself to blame for this condition, and there is little hope for relief until we have established definite standards to be followed in designing and constructing patterns for making steel castings. It is only by the establishment of such standards that engineers responsible for design and construction will recognize the existence of the fundamental requirements of patterns relative to the manufacture of steel castings.

A few foundries have taken the initial step in this direction by installing a systematic inspection of all patterns received and by calling to the attention of the customer patterns that are not suitable from a standpoint of intensive production and good castings. This suitability is not only for pattern construction, but for design as well, and when the customer knows that a foundry is conscientiously endeavoring to cooperate to the end of better castings and better production, he invariably concedes a well given point.

Foundrymen Must Co-operate

This education is very slow work when done by only a few foundries and it will require the concerted action of all to gain the end we are striving for.

Although different foundrymen seem to think they have many conditions peculiar to themselves, we believe this is largely a matter of imagination and prejudice. Their statements may be true if applied to the type of labor and kind of material available, plant lay-out, the machines used and methods of making steel, but these, especially the last three,

are usually determined by the kind or class of work in which a particular shop specializes. The problem of pattern design and construction is not peculiar to any one shop; in a broader sense the principles applicable to one are applicable to all.

A few years ago a suggestion of this kind would have aroused a storm of indignation from the various foundrymen holding conflicting views as to the best methods of making a casting, and also as to what constitutes a desirable design. However, with the broader minded men of today, we believe it would be possible to have all steel foundries of the same class adopt certain standards in this respect, providing they can be shown these standards will be productive of the best results.

Standardizing Stock Allowances

Let us take for example the amount of stock allowed for machining. Why should one foundry ask for ¼-inch finish allowance, another 3-16-inch allowance, while still another should be willing to make the same casting with only 1/8-inch or less finish? Why should it not be possible to establish a standard of finish allowance for different classes of work and have all patterns of that class made to standard in this respect? This would help the customer in placing patterns from one shop into another, inasmuch, as he could feel safe that they were correct in this respect and furthermore, foundrymen would not need to fight with every new customer to gain the required stock necessary to make a good commercial casting, merely because some impractical visionary had declared it to be possible to make steel castings without machine shop allowance for machine finish.

The question may be raised that, as different foundries have different methods of making similar castings, the allowance for finish would vary for different foundries. This might be true at the present time, but regardless of the job, there surely must be one best way to get a good commercial casting. Take into consideration molding cores, cleaning, yield, etc., and although these practices may vary in different shops, the one best way must necessarily appeal to all pro-

gressive foundrymen, and eventually, we hope there may be a standardized way of making all castings of any particular type.

Standardized Dimension Limits

Again take the cross section of metal in relation to its length and breadth. Why can we not establish a standard in this respect? Possibly some foundries have established such a standard, but if so, it has not been the writer's good fortune to be acquainted with them. However, we do believe it a possibility to determine upon a maximum and minimum limit in this regard, and one which would be of practical value to all. Obviously, this would eliminate many so called mean "undesirables" before they would be placed in the foundry, and much unnecessary work and expense would be saved.

At present each foundry is apparently a law unto itself, and a man in one organization considered very efficient and very capable, may be at a great disadvantage should he for any reason transfer his connections to some other foundry. Moreover, the knowledge of foundry practice to be gained through a course of study in any of our schools is elementary in the extreme. In comparison with other lines of industry there is less to be gained from a technical study of the foundry than that of any other trade, and this is probably largely due to the fact that there are no established standards that can be placed at the disposal of the schools.

Standards Would Help Schools

Although this phase of the situation is broader and more far reaching than is implied in the title of this paper, we believe that the standardization of pattern design and equipment should play an important part in training men for foundry work. It is by working along these lines that we can give such definite knowledge or data to the schools that they will be enabled to offer a course of practical value. By so doing, men of calibre will be interested, whose connection with the foundry industry would certainly be of benefit to all.

The writer has endeavored to treat this subject in a general way rather than in detail, as it would be necessary to first establish the fundamental principles of such a movement before taking direct action on any special feature of it. As

stated before, the writer believes that by stimulating discussion along this line it will be possible for the foundries to get together in a concerted movement, which will be productive of good results and will tend to raise the standard of foundry practice to a higher level, help us to eradicate the old rule-of-thumb methods and put the industry abreast of the times.

Discussion

MR. C. H. GALE.—I can see a great difficulty in getting foundries to agree upon any particular number of castings which would be required from a certain pattern. One pattern, for instance, might be good enough for five or ten castings but if the customer wanted several hundred or a few thousand castings, that would be entirely a different matter. There is where the question of pattern construction would be involved. I think we will all agree that we can make a few satisfactory castings from a certain pattern that could not be used for any great number, but will we agree as to just what that number is?

MR. R. J. DOTY.—I want to ask Mr. Gale in connection with his statement about the patterns being good enough for one or two pieces if he has had the same experience that I have often had, particularly in the manufacture of small steel castings. The customer will supply or order a cheap pattern, good enough for one or two castings, but not so constructed as to conform to good foundry practice. Yet, after he has received two or three castings he will send an order in for maybe two or three hundred and will oftentimes object to the making of a new pattern, because he already has sent the cheap pattern. It would have cost him no more money in the long run if he had had his pattern orginally built to some predetermined standard.

MR. C. H. GALE.—I have encountered that proposition very often. We frequently make castings in an experimental

way or for ourselves where only from two to six castings are required. We make a single wood pattern. Afterward an order is received for four or five hundred or a thousand.

"You have the pattern for it," they say, "go ahead and make it."

I say, "No, we have no pattern."

"Yes, you have, you made them before."

But I generally have my way in the end, although it requires some pushing to do it.

MR. K. V. WHEELER.—In reply to the question on finish allowance, isn't the variation sometimes due to the fact that different foundries make the same casting in so many different ways? If that is true, isn't it possible to determine on the best way to make any particular casting, and if such is the case I can see no reason why all foundries with fairly good practice can't adopt a uniform standard for finish allowance, and adhere to it.

A MEMBER.—Much depends on how the mold is rammed up. Suppose you had two patterns made exactly alike and you gave them to two different men, and one rammed them up hard and one rammed them up loose; you would have more finish allowance on one than you would on the other. That has a lot to do with it.

The Chairman, R. A. BULL.—Of course the temperature of metal plays some part in it too.

MR. JONES.—On a long casting the amount of finish should be a little more than on a short casting, especially if the ends of the casting were to be machined off. A slight variation in the pouring temperature, although the casting is supposed to be poured in fairly cool metal, would make some variation on the over-all dimension of a long casting. On castings of considerable length perhaps the finished dimensions should be more than on smaller castings.

MR. STEPHEN B. PHELPS.—Probably that difficulty is partly due to the variation in rapping. One man might rap a casting twice as much as the other, and you would get twice as much finish.

Some Details in the Molding of Small Steel Castings

By R. J. Doty, Milwaukee

There are few foundrymen who have not at some time felt that the effort of marketing their product would be considerably lessened could they always supply castings clean, smooth and free from interior defects. There are some who aside from the sales problem involved want to make steei castings better than they have ever been made before. All of us, for one reason or another, would make better steel castings if we could, and most of us are resolved to do so.

It is the purpose of this paper to present and discuss in a brief way, some of the problems which have a direct bearing on the qualities just referred to—problems which every foundry meets and contends with daily.

Given the best metal in the world, cast at the most suitable temperature, and provided with the most efficient means of feeding, it is impossible to get a clean, smooth casting, free from interior defects, unless you have a mold worthy to receive such metal. Without a mold you can have no casting, without the right kind of a mold, perfect metal cannot give you a perfect casting.

Importance of Facing and Heap Sand

It seems to me, therefore, that the problem which we must solve is the making of proper molds, and the making of such molds is a much broader proposition than is at first apparent. It is more than molding and the molder has control of but part of it. Briefly, it is the proper making of molds from proper facing and heap sand.

Although much of the following may be of interest to those casting steel into sand molds, it is particularly written for those who do green sand work and whose castings run from the lightest to one or two hundred pounds.

All steel foundrymen will agree that a good facing sand must be strong, open or porous, and that it must peel well

from the casting, but how many will agree as to the type of mill best suited for mixing this facing? Each type of mill has a following among steel foundrymen and every foundryman feels that his facing is good; yet how can this be if one type of mill is best?

Foundrymen also disagree as to the length of time a batch should be milled, and few actually know how long batches are milled. Some, in an effort to standardize, give instructions as to the number of minutes a batch should be run, but it is just as true that the operator depends more upon his judgment than he does upon the clock, that he will run it longer if he is not pushed by the molders or is tired and will cut it short if pushed.

Disagree on Equipment and Method

We are not, therefore, all agreed upon the type of mill best suited to our needs, nor upon the length of time a batch should be milled, but although some are getting better results than others we are all getting fair results and it is reasonable to assume that there is something more important to facing sand than the type of mill or the length of time it is milled. Let us see if it is in the ingredients of the batch.

Some foundrymen use crude sand, others washed and drained, a few washed and dried; some use sand from one district and some from another; to some a sand is fine, to others it is coarse; and in the same manner they differ on the subject of fire clay.

It is not the intention of the writer to say that one sand is as good as another, or that one clay is as good as another. There must be a best sand and a best clay. But how can we assume that one or a few of us are right and the rest wrong? There must be something which has a larger influence on our product than the different grades of sand and clay.

How many use the same proportion of new sand to old, or of clay to sand? How many use silica flour, and in the same proportion? How many use the same manufactured dry binder and in the same proportion? How many flour? How many the same liquid binder? How many molasses water, or oil and in the same proportions?

Let the writer answer by illustrations. In Milwaukee there are 12 or more steel foundries. No two use the same mixture nor the same proportions. It was my privilege recently, to examine a comparison of the facing sands used by a number of foundries making small steel castings. The average weight of castings produced by these foundries is very close and they manufacture castings for very similar lines of industries. It would be well nigh impossible to find any similarity in their mixtures. The proportions of new sand to total batch varied from 10 to over 40 per cent, the clay and other ingredients varying likewise.

It would be very difficult for anyone to say with certainty what are the best ingredients and best proportions to give the best results. However, that combination which is made up of a good refractory sand and the least amount of binder, which, with just milling enough to thoroughly mix it and bring the strength of the binder into play, will give good results, is recommended.

The writer cannot give the best mixture for any grade of work, but he can talk about a mixture which has given very good results under varying conditions and with different grades of silica sand and clay. The greater part of his experience has been with green sand castings and these castings have invariably peeled well, been free from scabs, etc. A large part of these castings were made in facing sand of which the following mixture is a fair example: Two hundred and sixteen quarts of heap sand, 24 quarts of new silica sand, 3 quarts of fire clay, 2 quarts of foundry flour and 4 quarts of silica flour.

Use Water Only in Tempering

From time to time the proportions have been varied slightly, usually to offset the difference in the heap sand, but the results have been the same. The variation when necessary is in the ratio of old to new sand only. The standard mixture as shown has a ratio of nine old to one new. This ratio is decreased to open up the facing but in no case has it been less than four to one.

This facing, like all others, will have to be watched

carefully for two things: It must not be too wet nor too dry, and it must not be allowed to become too close. The matter of dryness will take care of itself, for should it become too dry it will be impossible to use it. Should it become very wet, the molders would refuse to use it, but it is possible to have it too wet for good results yet very suitable for ramming. This condition can be prevented by careful training of the mill men and almost wholly prevented if the general foremen will make a practice of going to the mills to feel the sand at least once an hour, and if he will train himself and his assistants to take a handful of facing from occasional batches as they are delivered to the molders.

The matter of closeness is harder to watch but it is perfectly possible to know the condition of this sand by the sense of feeling and any foreman can soon train himself to recognize immediately a change in the openness of it. Until one has so trained himself and as a check after he has done so, the following water test is very reliable.

All foundrymen know that a handful of dry silica sand will take up water rapidly if allowed to fall on it drop by drop, and will continue to do so until saturated. This is not because the sand absorbs water but because of the many little interstices between the particles of sand into which the water runs—in other words, its openness. They also know that a place on the surface of a mold made shiny by too liberal tooling is very reluctant to take water, and water applied to it will be absorbed very slowly, or, will even lie there in a thin film. They also know that a facing which is too close—or in other words, in which the interstices between the particles are reduced in size and separated from one another by dust—will absorb water very slowly. Bearing these facts in mind it is possible to judge openness pretty accurately, if one will take a handful of loose facing, and holding it in the palm and applying pressure strike it sharply against a smooth surface such as the handle of a wheelbarrow or a much used shovel. This will have the same effect as ramming and if the sand be moved back and forth along the handle it will take a more or less shiny appearance on the

surface, such as tooling gives. Now, hold the sample in one hand with the smooth side up and inclined at an angle of approximately 45 degrees. From some container such as a can held in the other hand, allow water to fall rapidly drop by drop upon the sample. If one drop is absorbed before the next one strikes you may be sure that the sand is open and will vent freely, but should the water run down the surface spreading rapidly, you may be sure that your sand is too close to permit a free passage of gases.

Mixture Seldom Loses Strength

The mixture given will seldom loose its strength but it may become too close. It sometimes runs for as long as six months without a change and again it may be necessary to change it after a month or even a few weeks. This is probably due to changes in the character of work. A long run of light work where the ratio of facing to metal is high will result in the introduction of much unburned clay into the mixture, while a long run of heavy work where the ratio of facing to metal is low will result in the introduction of much burned and finely divided particles of clay and sand into the heap.

By carefully watching and testing, either of these conditions may be caught in time and the facing opened up by a reduction in the quantity of heap sand and an increase in the amount of new sand.

For convenience and accuracy in measuring, a 12-quart pail is used and the mixture already given, together with two other mixes calculated to open up the facing will appear as follows:

	No. 1	No. 2	No. 3
Heap sand, pails.....	18	17	16
New silica sand, pails...	2	3	4
Fire clay, quarts.....	3	3	3
Foundry flour, quarts....	2	2	2
Silica flour, quarts.....	4	4	4

It is very essential that the ingredients be accurately measured and for the sake of those who use some form of power loader, it will be noted that in each mixture the quantity of sand is the same. It is, therefore, possible to

put a removable partition in the loader bucket, so arranged as to make a compartment which, when level full, will hold 20 pails. Then by introducing the new sand measured by pails, 2, 3 or 4 as the case may be, it will be evident that the heap sand may be shoveled into the bucket and measured automatically, as it is the difference between a total of 20 and the 2, 3 or 4 pails of new sand.

Water Only Used for Tempering

Special attention is called to the fact that only water is used in tempering the mixture and that no liquid or dry binder other than those noted is ever used.

With sand such as this, the molds may be closed and poured immediately, or held for hours with equally good results, but should it be necessary to hold them open or, skin dry them, they should be sprayed lightly as soon as finished with weak molasses water or some binder such as dextrine boiled with water to prevent loose sand on the surface and corners. This loose sand, as you know, always appears when a mold is allowed to dry in the air or when heat is applied. In spraying, care should be exercised to see that it is stopped before the surface takes on a wet or shiny appearance.

If this sand is kept open as it should be, the castings will not only peel well but they will be agreeably free from cutting and scabbing. It is equally true, however, that such a sand is not a preventative of cutting, scabbing, blow-holes or those minute dark holes which appear under the surface when a casting is machined unless the heap sand and the molding are right. A sand such as we are considering will not cause such defects but it ought not be called upon to prevent them inasmuch as the function of a facing is to provide a surface against which and over which metal at very high temperature may be run without fusing with the sand of which the mold is made.

To prevent cutting, scabbing, blow-holes, gas pockets, and the minute dark holes which bother so many, we must have not only a proper facing but proper heap sand and proper molding.

In many foundries heap sand, if considered at all, is looked upon as a necessary evil, something with which to fill up the mold and its preparation is left entirely to laborers. It seldom receives attention from a foreman unless some molder complains about it. Usually the molder talks to the laborer and the foreman knows nothing of it.

It is safe to say that little thought is given to the important bearing which heap sand has on our castings. A molder complains that it is "no good," and in reply to our question as to the trouble with it, states that it is "too wet" or "too dry." We send a laborer to cut some dry sand with it if it is too wet, or some water if too dry, but we seldom examine it to see just how it is, or stop to analyze its effect upon the castings.

Heap Sand Must Be Porous

Heap sand is nearly as important as facing. It must have sufficient bond to knit with the facing and to ram well. It must be strong enough to permit of lifting the cope, of drawing the pattern and of meeting casting strains. It must, however, be open or porous to permit of the free and rapid passage of gases and steam which are a sure result of the casting operation, and are the cause of scabs, blow-holes, gas pockets, and those minute dark holes under the surface, which have been previously mentioned.

Some time ago in talking with some very good molders about venting I learned that it is unnecessary for all the air in the mold is sure to rush out through the heads before the mold becomes filled with metal. True, but what about the water in the sand, the air between the particles of sand, the gases formed during and after the casting operation? It is very evident that as soon as molten metal enters and fills up the mold the sand in contact with that metal rapidly takes heat from the metal and transmits it to the adjoining sand. The sand in contact with the metal comes to a very high temperature and that sand adjoining is likewise raised to a high temperature, the temperature of the sand at a given point depending upon the distance of that point from the casting and the size of the casting. Within a short time

after casting this temperature has increased to above the boiling point of water, and to that point where binders burn. Briefly, the interstices between the particles of sand adjoining the casting become filled with steam, hot air and gases, which soon build up pressure unless they find free passage to some other point.

Gases Follow Easiest Path

According to a well known law, gases travel along the path of least resistance and in the case of a mold all paths lie through the sand of which the mold is made. Picture to yourself a pocket of gas, increasing in pressure at a short distance from the molten metal but from 4 to 12 inches from the bottom board or the top of the cope. The pressure will force the gas to move and following out the law referred to, it will move toward the metal which is nearer unless the mold is a proper one, because the distance it must travel to find relief is shorter or in other words, the resistance is less.

In the case of very close sand it cannot move until the pressure is sufficient to overcome the resistance and since it cannot pass through the sand it must move it. As a result small explosions take place and portions of the mold surface are lifted off and we have a scabbed casting.

In the case of a mold of good facing but poor heap sand the action is different. To follow out the reasoning in such a case, it is necessary to realize that molten metal offers less resistance to the passage of gases than does close sand. The good facing is open and readily permits passage of the gases. These gases enter the metal and almost always leave their mark. In many cases it is easy to find the point at which they entered; in nearly all cases the point at which they stopped in the casting is readily discovered. It is my belief that those minute dark holes just under the surface of a casting and which often appear as pin holes on the surface, are the channels through which gas forced by pressure sometimes, or by seeping through the open sand of the mold surface, entered the metal.

In contrast let us consider a mold made from good

facing and good heap sand. Such a mold will be very open. Metal enters under pressure from the sprue, the air is forced out through the heads where there are heads, and through the open sand where there are no heads. The temperature rises, the water is changed to steam, the hot air and the gases generated by combustion, expand; but since the path is clear they move slowly and gently through the sand, emerging along the bottom board or through the cope where they ignite. Such a condition is ideal and a pleasure for true foundrymen to watch, but it is a condition which rarely exists unless the good facing and good heap sand are helped out by proper molding.

In discussing molding we shall talk only of two things. One aids the gas in passing through the sand and the other has great influence on the smoothness of the castings. I will refer to venting first, since we have just been considering open sand.

Using Vent Wire in Molds

In the best foundries sand cannot always be just right nor can the molding be truly uniform. Should every mold be jolted or squeezed without any hand ramming it would not be uniform because it is seldom that the depth of sand over the entire surface of the pattern is the same and even were it uniform under this condition, we should still have deep pockets increasing the distance which the gases would have to travel and thus increasing the resistance to their travel. Realizing this we must help out our good sand and our good ramming by the use of a vent wire.

This vent wire, a simple and inexpensive tool, is but little used. Why, I cannot say. It requires little effort to push it through the sand if the end is slightly enlarged and in that shape it will not injure the pattern. It requires but a moment to vent the drag and scarcely longer to vent the cope if the heads and sprues are not removed until after its use. If we but put one one-hundredth part of the thought and effort on the vent wire we expend on facing, we would be well rewarded. Our scrap piles will be smaller, our complaints and returns much less. Mediocre facing, poor heap sand

and a good vent wire will accomplish wonders. Good facing, good heap sand and a good vent wire cannot be beaten.

Referring to the smoothness of castings, you have seen castings where a portion of the surface was smooth as glass and adjoining such smooth parts, or sometimes surrounding them, are surfaces which look like sandpaper. Sometimes you may have seen castings smooth everywhere but in the corners or on irregular surfaces. On surfaces horizontal in the mold you may have noticed that a group of shallow bosses were smooth while the casting between them was rough. In each case the entire casting was faced with the same sand and since part was smooth why should it not all be smooth?

Obtaining Smooth Castings

The casting was smooth where the mold surface was harder. On the flat surface the rammer may have come closer. It could not get in the corners and neither could it get over the irregular surface nor between the bosses. It does not take a molder long after riddling on his facing to tuck it firmly in pockets and corners and to press it with his hands over the surface of the pattern. It is worth while and will result in much smoother castings. This tucking of the facing firmly against the pattern is one of the greatest preventatives of cutting known to the writer, for with a facing sand such as we have been discussing, backed up by proper heap sand or proper venting, there will be seldom any cutting action by the metal in front of the gates provided that they are proportioned well. All good foundrymen know how to regulate gates. It has been my experience that cutting is almost invariably due to the fact that facing sand before the gate was not packed firmly enough.

It has been stated early in this discussion that some foundrymen are getting better results than others and that we are working along widely separated lines. I have discussed a facing sand mixture with which I am familiar and which you may or may not be able to compare with your own. I have also told you of how we watch our facing and how we watch our heap sand. I have drawn these

comparisons because I believe that our troubles are not due so much to poor facing and poor heap sand as to the fact that our facing sand and our heap sand vary considerably.

Much thought and much effort has been given to the question of facing sand and many foundrymen have worked out mixtures which will give excellent results, but the writer believes that their effort has ended there instead of continuing down through their organization, and so training the men under them that they will consider and watch the facing with an earnestness equal to that expended by the man who has worked out the mixture.

Recently I talked to six men representing well known foundries. All felt that of the problems before the foundrymen, the question of facing was most important; all felt that facing sand has not kept pace with the steel casting industry. To my mind it has not kept pace in that our sand mixtures are less scientific than our metal mixtures, but in the fact that we do not watch our sand as carefully as we watch our metal. Should we do so and should we know that every batch is as carefully mixed and as carefully manipulated as are each one of our heats, then our facing sand would be as uniform as our metal and we would produce much cleaner, sounder castings.

This statement is made advisedly, because it is believed that the troubles with facing sand are not due to poor but to ununiform facing and this is the answer for which many of us have looked in attempting to explain why one lot of castings were good and another poor, both lots being faced with sand mixed to the same formula.

In conclusion allow me to say that this contribution to this meeting of the association is given in the hope that it will arouse in fellow members a new line of thought which will lead to concerted action by all to bring about a uniformity in that sand used by each foundry. Such uniformity cannot help but raise the standard of the industry and increase the production of castings clean, smooth and free from interior defects.

Discussion—Molding Small Steel Castings

MR. S. STONEHAM.—I would like to ask the speaker what he does with burnt sand when he has a lot of castings weighing from 100 to 150 pounds. Does he take a good deal to the cleaning room or does he rap the castings well before taking them from the foundry? If he raps his castings well, what is the result of using so much heap sand?

MR. R. J. DOTY.—We do both. We would like to rap all our castings well before they go to the finishing department, but unfortunately the laborers don't always feel the same way about it. The result is that the heap sand becomes closer, and we then open it up by the addition of new sand.

MR. CHISHOLM.—I would like to ask Mr. Doty if he feels it would be a good business proposition to have men check their facing sand the same as we analyze our heats. The reason why I ask is that I attempted to do that at one time, and I worked up a simple test whereby we could take a sample of sand from the pile and run the simple test, breaking, one by one, the 12-inch bars, but I never could get any encouragement.

MR. R. J. DOTY.—I have not thought so much about the fracture test, but I have thought a good deal about the porosity. It seems as though some way could be provided for taking a sample at regular intervals from the mill, and forcing air through under pressure and measuring the flow and the time. I think if we could do that we would save lots of money in the year on sand and clay, and a great deal more on castings.

MR. CHISHOLM.—I used a pipe 3 inches in diameter and 15 inches long and with a quarter inch opening in the bottom of the pipe to which was fitted a quarter inch nipple. I forced a certain volume of air through the sand in the pipe and noted the number of seconds that it took to put the air through the

volume of sand. I had a rammer three inches long and after filling the tube with sand and striking it off level, I tried to ram it down three inches.

MR. R. J. DOTY.—It would be a fine thing to make a daily test of it, I think.

MR. S. STONEHAM.—Mr. Doty talks about the venting and then gives a mixture of silica flour. Doesn't he think that the silica flour fills up the little space that give us vent with the processed sand?

MR. R. J. DOTY—The silica flour is very fine and does fill up the interstices, but in the limited quantity which we use it seems to have a good, rather than a bad, effect on the casting.

Making Steel Castings to Specifications

By E. R. Young Jr., Detroit.

Specifications for material are in most cases prepared by the purchaser. This is true of specifications for steel castings, but in the case of this material it frequently has been true that the purchaser decided what properties were obtainable and what standards should be set. Foundrymen in general have not, in the past, known as much as they should of the physical characteristics of their product.

With the demand of the last few years for castings of higher physical properties, the makers of steel castings have learned how to meet the new requirements and also have become alive to the desirability of their knowing as much as possible about the physical properties of their castings, as well as the methods of testing them. There is at the present time, a committee at work on the gathering of data from the different foundries and on a uniform series of tests to be carried out at different plants, information which is to be used in connection with a proposed revision of specifications.

Work of this kind is what is needed and cannot but result in raising the standards of the industry and in promoting a better understanding with the user of castings with regard to properties and specifications. The Detroit Steel Casting Co., along with many other steel foundries, has accumulated some information on the making of castings to specifications, which may be of interest to the steel casting section.

In order to make the discussion definite it is proposed to take up the work done under the specifications of the ordnance department for Nos. 2 and 3 cast steel, which required a minimum tensile strength of 70,000 and 80,000 pounds per square inch, respectively.

Working to these specifications a record was made of more than 1000 consecutive heats which met the requirements. An analysis of the data on these heats with regard to tensile

strength shows that 14 per cent of the total number of heats had a minimum tensile strength of 85,000 pounds per square inch and that 2.4 per cent had a minimum tensile strength of 90,000 pounds per square inch. A more detailed analysis of this data is given in Table I.

Table I

DATA ON 1028 HEATS OF CONVERTER STEEL

Range of tensile strength	No. of heats	Per cent of total	Average properties and analysis: Yield point	Tensile strength	Elongation per cent	Reduction per cent	Carbon per cent	Manganese per cent
90,000 and over..	25	2 4	49,660	93,286	19.78	23.16	.334	.817
85,000-90,000 ...	120	11.7	47,865	86,865	20.78	26.32	.309	.748
80,000-85,000 ...	369	35.9	44,909	81,900	22.21	28.57	.298	.720
75,000-80,000 ...	390	38.0	42,925	77,575	24.02	31.20	.285	.683
70,000-75,000 ...	124	12.0	41,173	73,505	25.40	34.73	.273	.654

Chemical Composition and Treatment

The steel was all made in a side-blow converter and was recarburized with cupola metal. The desired carbon content was 0.28 to 0.33 per cent. The steel was blown to a carbon content of about 0.08 to 0.09, the deoxidizing additions furnished about 0.05 per cent, and cupola metal was added to the extent of about 160 pounds per ton to furnish the remaining 0.16 to 0.18 per cent of carbon.

The only unusual point to be mentioned with regard to chemical composition or treatment concerns the use of titanium. It was found that the use of titanium in any form decreased the elongation and reduction and was to be avoided in quantities greater than 1 or 2 pounds per ton, depending on the titanium content of the alloy used.

In making lower carbon steel for miscellaneous castings the practice had been to use about 1 pound of titanium alloy per ton. This amount was increased when beginning this work, with the idea of insuring greater solidity. Trouble in securing proper ductility was encountered and ascribed to various causes, until finally the amount of titanium being used was reduced, whereupon the ductility immediately improved. The data given in Table II show the results of using various quantities of titanium.

The untreated steel was actually superior in physical properties, and titanium was used only as an additional deoxidizer and scavenger, as a precautionary measure.

The annealing was done at a temperature of 1650 degrees

Table II

Effect of Use of Various Amounts of Titanium

Heat No.	Physical properties: Yield point	Tensile strength	Elongation in 2 in. per cent	Reduction of area per cent	Analysis: C.	Mn.	Si.	P.	S.	Treatment: Wt. Titanium Alloy per ton of steel
450	50,000	92,250	24	32	.37	.77	.37	.059	.051	None
A	54,000	90,000	12	12	.38	.77				3¼ lbs. carbon free alloy
B	56,000	92,250	20	23.7	.40	.72				7½ lbs. ferro carbon alloy
150	40,000	68,750	32	43	.18	.77	.30	.062	.063	None
A	40,750	67,350	24	27	.18	.77				3¼ lbs. carbon free alloys
B	41,950	74,000	19	20	.20	.73				7½ lbs. ferro carbon alloy
200	41,250	67,250	27	33	.23	.55	.25	.059	.079	None
A	36,500	66,100	22	23	.23	.56				3¼ lbs. carbon free alloy
B	38,500	69,750	26.5	34	.25	.57				7½ lbs. ferro carbon alloy
3	38,750	75,500	28	43.5	.28	.74	.25	.070	.038	None
A	40,500	76,000	28	41.8	.28	.74				¼ lb. carbon free alloy
B	40,000	76,250	27	42	.28	.74				2 lbs. ferro carbon alloy
C	40,200	75,740	27	41.2	.28	.74				1¼ lbs. alumino titanium
1	41,000	66,000	34	57.5	.15	.70	.33	.056	.069	None
A	47,000	67,250	32	50.8	.15	.69				(10 oz. aluminum)
B	45,500	68,900	32	46.9	.15	.70				2 lbs. ferro carbon alloy
8	39,750	64,750	29	47.2	.15	.65	.29	.063	.080	1 lb. carbon free alloy

Fahr., the castings being held at this temperature for about two hours, and furnace cooled. A few heats, in which the carbon and manganese content were both rather low, were air-cooled from 1650 degrees Fahr. and reheated at a temperature of about 1300 degrees Fahr. Otherwise there was no variation from a simple annealing treatment.

The tests were made on the usual type of test specimen machined from a bar 1¼ x 1¼ x 8 inches. In cases where the castings were of too small a section to permit of attaching a test bar directly, test bar blocks were used. These blocks were cast in a mold with a casting and gated securely to it. The type of block used was 4 x 6 x 8 inches with two bars attached to the lower face. The dimensions of the bars were 1¼ x 1¾ x 8 inches, which gave a bar approximately 1¼ inches square after being removed from the casting or block. The bars were cut from the block by the use of an acetylene torch after annealing with the castings attached.

Process of Steelmaking Not of First Importance

The fact that the entire series of 1028 heats was within the specifications shows that it is possible to consistently maintain a fixed standard of quality in steel castings. The fact that the converter process was used proves that the method of mak-

ing the steel is not of first importance in work of this kind, but that satisfactory steel castings with special properties can be made by the converter process, as well as by the open-hearth or the electric process.

To maintain the desired standard and to successfully meet the tests to demonstrate it, it is necessary not only to carefully control the chemical composition and heat treatment, but also to watch the details of preparing the test specimens.

The writer wishes to discuss these details somewhat more fully, as well as the general question of test specimens. The first point to be emphasized is the importance of securing a sound test bar. Specifications are based on the properties of a solid, uniform piece of metal, and the foundryman is only doing himself and his product simple justice when he takes great care to secure this solid, uniform piece of metal. Too often test bars are cast without an individual head or riser, but are merely gated to the casting and fed from one end. There is very little chance of such bars being sound. When it is possible to attach the bars directly to the under side of a heavy section of a casting this is the preferred method, but in other cases a test bar block of ample size to properly feed the bars should be used.

Make Test Bars in Mold

It is desirable to make all test bars and test bar blocks in a mold, and not in a core. If made in a core they are subject to porosity because of the gases evolved from the core, and even though the possible occurrence of this difficulty is entirely obviated by ideal practice, such cores are apt to be kept in stock and to accumulate moisture while standing, and thus cause porous bars.

When made in a mold, and especially when at the bottom of a large mold, care should be taken that the test bar impressions are not partially filled with sand or with mold wash which has drained into them. If attached to a large casting and "necked down" to aid in breaking off, the neck should not be too narrow or a "shrink" in the bar will result.

At the foundry of the Detroit Steel Casting Co. it has been found desirable to eliminate all test bar cores and to use

the cutting torch or saw in removing all bars from castings or blocks. When broken off with a sledge there is always the danger of invisible cracks extending into the bar, which do not become evident until the bar is machined or actually "pulled." There is no legitimate objection to cutting, on the grounds that the test specimen will be affected by the heat of the cutting operation, as an investigation of this heating effect showed that at the center of the bar where the 0.505-inch machined section would be located, the temperature reached a maximum of 420 degrees Fahr. when the cut was made at a distance of approximately ¾-inch from the center, and a maximum of 290 degrees Fahr. when cut at a distance of 2¼ inches from the center.

When specimens for both a tensile and a bend test are required, it is convenient to increase the depth of bar itself to 3 inches, and cut in two lengthwise, using the lower part for the tensile test and the upper part for the bending test. This method was used successfully on considerable work done under navy specifications.

When it is necessary to cut a section out of a casting to be used as a test specimen, the section chosen should run horizontally in the casting as originally located in the mold, and not vertically. If the section chosen is a vertical one, shrinkage is almost certain to appear in the center of the specimen, after testing. This choosing of the specimen is entirely legitimate, as shrinkage is certain to occur in the center of some of the heavier sections of a casting, and allowance is made for it in good design, but the properties required of the test specimen are those of solid metal.

In support of this last statement the case of some tests on draw bar yokes may be cited on which the total strength of the castings themselves was specified as well as the properties of the steel. Specimens taken vertically were unsatisfactory when tested. Those taken horizontally were satisfactory and the total strength of the yokes when tested was above that specified.

A final point that might be made on the desirability of sound and representative test specimens is the minimizing of

re-tests which are bound to create an unfavorable impression on the representative of the purchaser, even when the retest is entirely allowable.

It is well before leaving a discussion of specifications and methods of meeting them to emphasize the fact that specifications and tests only determine the quality of the steel and not the quality of the castings themselves. It is generally admitted that good foundry practice is much more important than slight variations in chemical composition or physical properties, and that it is much more of a guarantee of satisfactory quality. It is true, too, that more difficulties are encountered in the foundry in establishing good practice than in meeting specifications. One reason is that most castings are made under specifications for low carbon steel, which are easily met. But until there is a greater general confidence among engineers and metallurgists in steel castings as such, the demand for castings of higher physical properties and especially for heat-treated castings will continue to be limited. The confidence of designers in steel castings has been strengthened by the higher standards of quality now prevailing in the steel foundry compared to those of some years ago, and its still further upbuilding by continued improvements in foundry practice should receive the most painstaking attention of steel casting industry.

In conclusion, the writer wishes to acknowledge his indebtedness to Elmer E. Mains, metallurgist, who was in charge of all the production work described.

Discussion

MR. H. P. TRAPHAGEN.—I want to contrast that method of inspection outlined in the paper with that of Lloyds. Lloyds' representatives come into your foundry and you want to show them the laboratory, and they will say, "No thank you, we don't care to see it." You volunteer to show them the testing machine. They don't care to see it. They will go down into the foundry and pick out half a dozen castings anywhere in the shop, take them out into the yard, and smash them to

pieces. Then if they are satisfied with the raw materials, the methods of melting, the men in charge, you get on the preferred list.

MR. E. R. YOUNG.—Our foundry is on the preferred list of the Lloyds' inspection. I think that in castings of intricate design, it is true that you have quite a variation in the solidity and density of texture of the metal, and when you cut a piece out of a casting, as requested by an inspector, it is only sensible to cut out a piece that has been cast in the same plane, you might say, which is not a vertical section.

PRESIDENT C. S. KOCH.—In Washington two years ago we ran up against the very same thing. Some of the members of the engineering division of the Ordnance department assumed that these bars should come from castings. It only took about an hour's time to show them that they were working in the wrong lines and that the foundry in no way guaranteed the strength of a casting. All it could do was to guarantee the strength of the steel which went into the casting, and the foundry in no way took any responsibility for design. There was no further trouble regarding test bars from a casting.

Cleaning Castings in a Steel Foundry

By A. W. Gregg, Harvey, Ill.

In the majority of steel foundries it costs as much or more to clean the castings and prepare them for the shipping platform as it does for the molding and coremaking. The finishing department is usually a source of continual worry to the foundry superintendent and is the place where delays are most apt to occur. It is easier to get a casting molded and poured than it is to get it through the finishing department but in many shops there is a tendency to feel that the job is out as soon as the molds are poured, in spite of the fact that an uncleaned casting is of no more use to the machine shop or customer than the mold in which it was cast.

Cleaning Room Labor is Scarce

Probably the greatest problem which the finishing department is called upon to solve lies in securing labor. The work is hard and disagreeable under the very best of conditions, and the class of labor which can stand the wear and tear of a steel foundry finishing department is always scarce, especially so with the present restricted immigration. The remedy obviously lies in making the surroundings as pleasant as the nature of the work will permit and in using all the labor saving machinery which the market affords. The day has passed when men will put up with dusty, unsanitary conditions even for exorbitant rates of pay. Fortunately, the machinery in the modern chipping room is infinitely better than it was 10 or 15 years ago. The old sand-blast room was a man killer which only the hardiest might survive, and the old fashioned stave tumbling barrel with its lack of an exhaust system, made its entire vicinity a dusty misery. Even grinding wheels are now connected with an exhaust system and tuber-

culosis is no longer a necessary or even prevalent disease among foundry operatives.

Lighting, heating and ventilation in a great many foundries have not received the attention which their importance merits, but it is more generally recognized every day that the foundry should not be, and is not necessarily, a dirty, dusty, ill-lighted place where a man works because be cannot find any more congenial occupation.

Kind of Floor is Important Factor

The kind of floor and the method of transportation for castings in the finishing department require careful study. In this connection the class of work is the important factor to be considered. Where the work is light enough to be handled by hand, creosoted wood block makes the best floor which can be put down. With a good floor it is possible to use the lifting truck for transportation and this is the neatest and cheapest method which has ever been devised for handling small steel castings. Where heavy castings are produced they must be handled with a crane and the floor in this case is not of such great importance.

In a steel foundry of any size proper organization demands that departmental lines be strictly drawn. Following the natural classification of the work, the operating departments are:

1. Metal department
2. Molding and coremaking departments
3. Finishing department

Each of these departments has numerous subdivisions. The metal department's responsibility ends with the delivery of sufficient molten metal of proper composition and temperature to the molding department. The molding department is held responsible for setting up the molds, pouring into them the molten metal, shaking out the castings and delivering them to a definite location in the finishing department. It is very essential that each department be held to strict accountability for definite and well defined operations.

The system of subdividing the work should be followed in each department, and a great deal of confusion and waste of labor is avoided if a very definite plan of operations be adopted. Especially is this true of the finishing department which at its best appears to the layman as a very disorderly place indeed, and perhaps a good many of them are open to this reproach. One steel foundry with which the author is familiar adheres so rigidly to a definite plan of operation that all castings are put through the sand blast whether necessary or not; the claim being made that it is less expensive to sand blast than to sort out and short-cut the occasional castings which peel out sufficiently clean to make the sand blast operation unnecessary.

Routing of Work is Important

It is impossible to lay out a system of routing which will be best for all conditions, but the following probably will satisfactorily meet the conditions found in most steel foundries. We will assume that the molding department is held responsible to shake out the castings, block off the loose sand, and deliver them to a definite location in the finishing department.

First operation, flogging. Gates and light risers are broken off with a sledge, first being nicked with a chipping hammer. Large cores are knocked out or loosened up on the flogging floor preferably with a heavy pneumatic chipping hammer used with a long chisel. If the castings are light enough to be handled by hand a power sprue cutter is a great labor saver. The gates and scrap which accumulate from the flogging operation and the sprue cutter should not be thrown upon the floor, but collected in boxes. If a charging machine is used at the furnace, the charging boxes should be used, if not, dump buckets which can be handled by the crane and readily transferred to the stock yard or charging platform. This saves one handling of scrap material and prevents a mussy accumulation which is a waste of floor space.

Second operation, sand blasting. The sand blast equipment should be carefully selected to conform to the class of work. Great improvements have been made in sand blasting

machinery in the last few years and the foundry now has a selection of several different types adapted for light or heavy work. All modern sand blast rooms have an exhaust system which changes the air four to five times per minute. The sand falls through the grating in the floor, is automatically elevated, screened and returned to the pressure tank. It is important to secure the proper quality of sand, and attention should be given to the use of the proper sized nozzle. Compressed air is expensive and its consumption should be carefully watched.

Cutting Risers With Torch

Third operation, flame cutting risers. After sand blasting the risers are removed with the flame cutter. The oxy-acetylene torch is used almost universally for cutting risers and heavy gates from steel castings. This can become a very expensive operation if the consumption of oxygen and acetylene is not given careful attention. The natural tendency of the operator is to use a larger tip and a higher pressure on the gas than is necessary, for this makes the cutting easier and more rapid. A small bonus to the operator based on economy in the consumption of gas is usually very beneficial. Some foundries prefer to cut the risers from castings before sand blasting to economize room on the sand blast car or table. When this is done a chipper must remove sand where the cutting is to be done, as the operation of the torch is interfered with by the sand adhering to the risers.

Fourth operation, welding. If welding is necessary it should be done at this point. The electric arc welder and the oxy-acetylene welding outfit are to be found in most steel foundries, although not given especial prominence when visitors are taken through the shop. The electric weld is made more rapidly and at considerably less cost than the gas weld, although the gas weld when carefully made is considered somewhat more reliable. No welding should be allowed except by instructions from the inspection department and should always be followed by annealing to remove internal strains caused by the high local heat of welding.

Fifth operation, annealing. The castings are now ready

for the annealing furnace. Practically all foundries are now using oil-fired annealing furnaces of the car type, although coal and gas-fired furnaces are in use in many foundries and powdered coal and producer gas are used to some extent. All steel castings without exception should be annealed, and the proper temperature, length of time and manner of cooling should be adapted to the composition of the steel under the supervision of a competent metallurgist. A reliable pyrometer installation is essential. The use of cast iron or steel grids increases the capacity of the annealing furnace by allowing the castings to be unloaded while still too hot to be handled in any other way, and the next charge being ready on another set of grids allows the furnace to be recharged at once, thereby saving considerable fuel. Careful attention to the type of oil burner and economy in the use of oil is very essential in these days of high priced fuel. The annealing furnace should be so designed that the flame does not impinge directly on the castings and so that it is possible to heat uniformly all parts of the annealing furnace. An oxidizing flame should be avoided as it causes excessive scaling.

Sixth operation, sawing risers. This operation has been eliminated by the flame cutter in the majority of foundries but where heavy castings with large risers are produced saws are used for their removal. When this is the case the risers are sawed off after annealing. This is especially necessary where high carbon or alloy steel castings are manufactured. When the flame cutter is used the risers are removed before annealing to economize room and oil in the annealing operation.

Seventh operation, chipping. The castings are next delivered to the chippers who remove fins and lumps with pneumatic chipping hammers. Small castings are chipped on benches equipped with vises to hold the work in place. Larger castings are chipped on the floor or on horses.

Eighth operation, grinding. The lumps usually left where the risers have been burned or sawed off, and where the gates have been broken, are removed on the grinders. Swing grinders are essential for large castings and stand grinders are used for the lighter work. In order to economize in the use of grinding wheels it is well to have two or three different rates

of speed for the grinders, the new wheels being used with the slowest speed and moved to the grinders with higher speeds as the wheels wear down. This also promotes grinding efficiency by maintaining a relatively uniform peripheral speed as the diameter of the wheels is reduced in grinding.

Ninth operation, tumbling. The final operation in the finishing department should be to tumble all castings whose size permits them to go into the tumbling barrel. This removes annealing scale and produces a bright clean surface on the castings. Castings too large for the tumbler should be sand blasted. The tumbler however, furnishes a much more presentable casting and tumbling is a far cheaper operation than sand blasting. In some foundries where the nature of the work permits, the tumbler can replace sand blasting.

The castings are now ready for final inspection, sorting and weighing. Inspection at every operation is a very important part of finishing department work. First inspection should be made on the flogging floor and castings which are obviously defective rejected at this point. It is hardly necessary to state that the inspection department should endeavor to reject imperfect castings before much work has been done upon them. Some defects do not show up until after sandblasting so an inspection is necessary after the castings leave the sand blast. At this point also the castings on which welding is necessary and allowable are marked by the inspector.

The foundry foreman should be constantly in touch with the inspection department and the foreman of the finishing department, not only for information concerning defective castings, but also to study the possibilities of decreasing labor in the finishing department by changes in gating, elimination of unnecessary fins, and to observe how the facing is peeling from the castings. Here an ounce of prevention is worth many pounds of cure. It is often cheaper to scrap a casting than to clean it up.

Without doubt the finishing department is the most difficult part of the foundry in which to introduce a piece work or bonus system of payment. The amount of work to be done on castings from the same pattern varies from day to day

with the condition of the molding and core sands, and the care taken by the molders. Especially in the foundry which produces a wide range of castings is the task of setting rates extremely difficult. The writer has tried day work, premium system, piece work, and various bonus systems. Some conditions demand a combination of all of them. There is no department in the foundry where a system of bonus payment or piece work is so necessary, for the output of a man working day work is invariably doubled when he is given a rate. In the writer's experience, piece work based upon the tonnage of castings handled produces the best results. A liberal rate is better than one which is too close and some flexibility in the rates must be allowed to provide for faulty conditions of facing sand and molding practice which cause extra work in cleaning the castings.

Piece rate systems of payment in the finishing department have a very salutory effect on the molding and coremaking departments, for the chipping room boss will certainly make a first class pest of himself when castings come to him with an unusual amount of fins, scabs or lumps or when the cores are too hard. When the chippers have difficulty to make their day's pay the rest of the shop is sure to hear all about it. When the piece rate system is introduced it is necessary to tighten up on inspection at once, and the inspector should be called upon to O. K. the piece workers' earnings.

A finishing department of any size should have its own tool and store room. Grinding wheels, hose, sand-blast nozzles, saw teeth, waste and lubricants should be stored here. Very few chippers are capable of properly grinding their own chisels and a supply of ground chisels ready for use should be kept on hand. All pneumatic chipping hammers should be returned to the tool room every night and given a kerosene bath. The cutting torches, regulators and hose should also be in the tool room when not in use.

This paper is not written with the idea that it contains anything which is particularly new to the steel foundryman. It is hoped, however, that it will be a stimulant to thought and direct some attention to the department which the writer has found to be the most troublesome in the steel foundry.

Discussion—Cleaning Castings

A MEMBER.—I would like to ask Mr. Gregg how he arrives at the amount of oxygen used, if it is per ton or otherwise.

MR. A. W. GREGG.—We have tried it both ways—by square inch and tonnage. Where the work is repeat work, and fairly uniform, you can use the tonnage system, and if it is irregular, you will have to use the square inch.

A MEMBER.—How cold do you allow the metal to get in the annealing furnace before you draw it?

MR. A. W. GREGG.—That opens up a large discussion. If you leave the castings to go black in the annealing furnace you will have a lower tensile and the greatest elongation and reduction you can get. I believe the best practice for low carbon steel castings is to pull them from the furnace when they are still hot, heat through the critical range and then pull the car right out. Sometimes you have to be governed by conditions. I know one shipping room where the roof is so low they can't pull the car out right away because it would set the roof on fire.

A MEMBER.—We anneal at 1650 degrees and thoroughly soak them.

MR. JONES.—I notice that the sixth, seventh and eighth operations come after annealing. It has been my experience that we sometimes find defects that have to be welded in these operations, which would mean that the castings would have to be welded and then re-annealed. I was wondering whether Mr. Gregg thought that was the way it should be done. We put these before the annealing.

MR. A. W. GREGG.—I wasn't attempting to lay out a plan of routing for all steel foundries, but what I was trying to emphasize was there ought to be a routing plan, and the castings would move from one operation to the other, and, as far as possible, you do all your welding before you anneal. Of

course, occasionally you will find defects cropping up that will require later on a weld, and you will have to re-anneal and unless it is a very insignificant weld.

MR. R. J. DOTY.—I think it is better to grind and chip before annealing.

MR. A. W. GREGG.—The reason I don't agree with Mr. Doty on chipping is because I think you can cut your chipping expense, especially if your carbon is all high, if you anneal first; your chipping is then done so much easier.

MR. R. J. DOTY.—Mr. Gregg's point is well taken, but I believe that the added cost of welding after annealing, re-annealing and re-tumbling more than offsets any difference in cost in the chipping operations, due to a higher carbon content.

PRESIDENT C. S. KOCH.—I understand you to mean there would be a difference in the appearance of the castings; it shows where they have been ground, in other words.

MR. R. J. DOTY.—I think that is true, but I was referring more particularly to the added handling and the repeated operation. We find that a good many of our defects will not show up until the padding under the riser has been removed, sometimes until the gater has been thoroughly ground down.

Report of A. F. A. Representative on Joint Committee on Investigation of Phosphorus and Sulphur in Steel

Your representative on the joint committee on investigation of phosphorus and sulphur in steel submits the following report:

It will be recalled that at the last convention of the association the members went on record as favoring, if possible, participation of the American Foundrymen's association in the phosphorus and sulphur joint investigation. Correspondence with the chairman of this investigating committee finally resulted in formal invitation by the joint committee to have the American Foundrymen's association participate through the selection of one representative. President Koch thereupon appointed the writer to act in this capacity. The joint committee now consists of 16 persons representing the following organizations: United States bureau of standards; United States war department; United States navy department; American Railway Association; American Society for Testing Materials; Association of American Steel Manufacturers; National Research Council; Society of Naval Architects and Marine Engineers; Society of Automotive Engineers; Steel Founders' Society of America; and the American Foundrymen's association.

Your representative was appointed by the chairman of the joint committee as a member of the committee on statistics, whose function it is to secure all possible information concerning the effects of phosphorus and sulphur on steel. Other committees are those on tests, manufacture, finance, and publicity. Dr. George K. Burgess, chief of the division of metallurgy of the Bureau of Standards is chairman, and C. L. Warwick, secretary

of the American Society for Testing Materials is secretary of the joint committee.

Considerable work has been done in securing data, and specimens which have undergone service tests, and in the manufacture of special material for investigation. It is not necessary to here supplement what has previously been reported in the technical press by the committee on publicity concerning the activities of the joint committee. It is, however, pertinent for me to say that the work is progressing energetically but will naturally require much time before it is concluded. The make up of the joint committee is such that it is hoped all producing and consuming interests will accept the findings.

There has been only one meeting of the joint committee since your representative became a member thereof. He then offered a suggestion which was approved and is of interest to this association. It is planned to issue a questionnaire to the steel casting manufacturers requesting that they set aside suitable steel castings which contain high percentages of phosphorus and sulphur which are occasionally made in heats that are "off" in analyses. The idea is thus to accumulate a suitable number of steel castings to ascertain by testing the effects of phosphorus and sulphur in cast steel. The questionnaire will indicate the sections desired which may be cut from the castings, and will go into the matter of annealing, as well as the history of the heats involved. Your representative urges all steel casting manufacturers irrespective of their membership in the association to co-operate in the suggested accumulation of material for such an important purpose.

Your representative will co-operate in the fullest degree with the representative of the Steel Founders' Society, who strongly favored the participation of the American Foundrymen's association in this joint investigation.

R. A. BULL, *Representative.*

Report of A. F. A. Committee on Specifications for Steel Castings

Your committee on specifications for steel castings has been mainly employed during the past fiscal year in keeping in touch with the discussions and movements which might have, in the future, some influence on those specifications with which the committee is concerned.

There has been no occasion for the committee to co-operate with a similar committee of the American Society for Testing Materials or any other body in the actual framing or modification of specifications. The specifications of the American Society for Testing Materials and of most large consumers of steel castings now stand as they did a year ago, the American Society for Testing Materials having decided at its meeting last June to continue for another year a maximum limit of 0.06 per cent for both phosphorus and sulphur in steel castings.

A subcommittee of the committee on steel of the American Society for Testing Metals was organized during the year, having representatives of steel casting manufacturers and the American Railway association to consider changes in specifications for steel castings for locomotive and car equipment. Your committee has kept in as close touch as possible with the activities of the said subcommittee which has been quite active but which has reached no conclusion that has been accepted by the main committee. It is probable that a comprehensive report concerning this matter will be made before the next meeting of the American Society for Testing Materials.

It is proper now to point out the growing importance given by engineers to the matter of the true elastic limit of steel, and to recommend to the members of this association that individual investigations of extended character be made to determine the relation between the true elastic limit and the other physical properties of steel. The art of testing has not reached the stage where the average operator can be relied upon invariably to report the true elastic limit. It is well that the steel casting industry quickly, experiment along this line, pending

the time when the true elastic limit may be a much more important factor in specifications than at present.

It is not out of place to here state that the use of the Berry strain-gage in determining elastic limit, has extended among testing engineers. Your committee regards it as most important when reporting the elastic limit to state how it was determined. We are hopeful that at no distant time a reliable method of determining this property may find universal acceptance in the most scientific circle and yet prove to be one which can be practically applied with the least possibility of error, and loss of time in testing. The committee considers it advisable to here emphasize the fact that the yield-point determined by the drop of the beam of the testing machine does not often coincide with the result obtained by an extensometer or by a strain-gage, the yield point almost invariably showing a higher result.

Believing in the inconsistency of specifying physical properties in conjunction with chemical composition, (except maximum limits for phosphorus and sulphur) your committee proposes to exert its influence against specifying limits for carbon, manganese, and silicon. It also believes in the wisdom of adhering to the present limit of 0.06 per cent for phosphorus and sulphur pending results of the present joint investigation of phosphorus and sulphur in steel.

There is no disputing the fact that the quality of the metal in steel castings was materially improved in many plants during the war. This had an important effect upon the attitude of many consumers. Some of these are desirous of prescribing more rigid specifications for steel castings; and it is problematical just what the effect of this attitude may be in the near future. It can be truthfully stated that the average steel founder endeavors to continually improve the quality of his metal and that he will broad-mindedly co-operate in future efforts to frame specifications that will provide the best quality of cast steel which can be commercially produced.

JOHN H. HALL
W. C. HAMILTON
A. J. JAMESON
J. B. NORDHOLT
R. A. BULL, *Chairman.*

A Novel Core Oven

By Stephen B. Phelps, Pittsburgh

Foundry superintendents in the past were not only expert in foundry practice but were required to have ability to design and construct their equipment as well. The present day foundryman as a rule does not have to use his ingenuity in designing machines, ovens, etc., because the many equipment manufacturers with their numerous standardized designs can usually supply his needs from stock and thus allow him to concentrate on such matters as production and quality of castings. However, it sometimes happens because of lack of space, peculiar operating conditions, or immediate needs, that the foundryman still has to be his own engineer. Such was the case when the writer was called upon to replace an oven which had been blown up, due to the carelessness of the colored operator, shortly before the writer took charge of the shop.

Heat Warps Tracks and Trucks

One of the disadvantages of oil burning for baking cores—especially, if as in this case there is not enough room for a well designed combustion chamber—is the intense heat developed which causes frequent relining of the combustion chamber. If the oven is of the truck style with wheels attached, and especially if the burner operates between two trucks, the rails, wheels and truck itself may be cracked and twisted out of shape by the heat.

Due to the lack of space the trucks in this oven were crowded too close together and the heat cracked the wheels, warped the truck frame and twisted the rails to such an extent that the repairs were very excessive. It frequently took about 20 men with chains and a man on each wheel with a bar to get the truck out and sometimes even this gang gave up. When properly lubricated the truck described below can be pulled out by two men.

The truck does not run on rails but is carried by trolleys which run on overhead I-beams. This novel idea eliminated the trouble in operating the trucks by placing the running gear and tracks where the heat could not affect them.

The new design besides giving quick service for cores, pays for itself in about two years by very greatly reducing the cost of repairs and the saving of the time of the excessive number of laborers and coremakers required to move the trucks.

The trucks are designed with the doors attached forming the end of the truck so that when one truck is drawn out for a new load, the back end of truck acts as a door and closes the oven, permitting access to one truck while the cores on the other truck are baking. This presented another problem in design as the trucks could not be drawn completely out of the oven and in this case it is not practical to build a longer oven or design another complete truck. In order to overcome this difficulty the writer designed two brackets for carrying the front end of the truck and a similar pair for the back end, but in this case the brackets and the trolleys extended through the rear wall, cast iron covers being designed to enclose them. This permitted the use of the entire oven space and the former truck frame which was designed with adjustable bars for carrying cores of different sizes.

Construction of Oven

The construction for the new oven for overhead travel consists of three columns erected along the side of the oven and three cross beams supported by the columns and the wall on the other side of the ovens. Four I-beams are suspended by turnbuckles from the cross beams to act as tracks for the trucks. The tracks are kept from swaying when the trucks are moved by braces connecting them with the columns and walls. Turnbuckles are used to suspend the tracks to insure their being level and to make them adjustable in case anything should throw them out of line. They are convenient but a less expensive hanger could be used. The three columns are tied together with a long angle and the same shapes are used as braces from the columns to the tie piece. The cross beams are tied to the wall with bolts.

It may be thought that these structural pieces were an additional expense aside from the building of the oven. However, it will be seen that in nearly each instance they or some other shape would be required if the usual type of oven were being built and some other pieces not required in this design would be used in addition. For instance, the overhead I-beams replace the tracks in the floor and do not require the customary metal ties or spreaders, nor the customary cement foundation which usually also means a cement floor. The columns replace the customary buckstays and the cross beams replace tie rods, although their costs no doubt are greater.

Three doors were hung on hinges on the walls of the oven to permit observation of the cores and the combustion. They also act as a vent so that the doors can blow open in case another careless operator causes an explosion. Standard trolleys were used in this case but they are not designed for such service and should be provided with special means for convenient lubrication in such close quarters.

Heat Treating Steel Tractor Castings

By Fred Grotts, Peoria, Ill.

The heat treatment of steel castings has been developed to such an extent that where formerly parts were made of forgings and cold rolled steel, now treated castings can be substituted at a reduction of cost and with satisfactory results.

Annealing was at one time considered the only treatment applicable to castings. It consisted in heating the material to above the upper critical point and holding it there for varying lengths of time, according to the kind and quantity, then cooling slowly. This procedure was intended to break up the original austenitic condition, which is brittle and hard, into a mixture of ferrite and pearlite which resists shock and is soft.

Castings Were Treated and Tested

Inability to obtain forgings and unsatisfactory results from annealed castings gave rise to intensive research on the advisability of heat treating castings of different analysis. With this idea in view, low, medium and high carbon steel castings as well as chrome-vanadium, chrome-tungsten, chrome-nickel and manganese castings were obtained and tested with gratifying results in each case.

Low carbon castings as shown in Fig. 1, having analysis of carbon 0.18 to 0.22 per cent; manganese 0.55 to 0.65 per cent; sulphur, 0.05 to 0.06 per cent; and phosphorus 0.04 to 0.07 per cent, after annealing at 1650 degrees had a tensile strength of 65,500 pounds per square inch, a yield point of 33,900 pounds. elongation of 21 per cent and scleroscope hardness of 24. The fracture was very coarse and crystalline. After heating to 1600 to 1625 degrees Fahr. and quenching in water they had the following properties: Ultimate tensile strength 76,800 pounds; yield point, 47,900 pounds; elongation, 16 per cent and scleroscope, 30. In some cases it was necessary to fabricate parts that were shock resisting in some sections and hard for a

ever, were in the annealed state. The casting shown in Fig. 3 is a low-carbon cast steel gear containing 0.20 carbon, which always had been case hardened. It was packed in carbonizing material for about eight hours at a temperature of 1700 degrees, then cooled and reheated to 1625 degrees, quenched in oil, again quenched from 1450 degrees in water and then drawn to a scleroscope hardness of 75.

The medium carbon steel is best illustrated in the track shoe, Fig. 4. This part weighs about 50 pounds, has in-

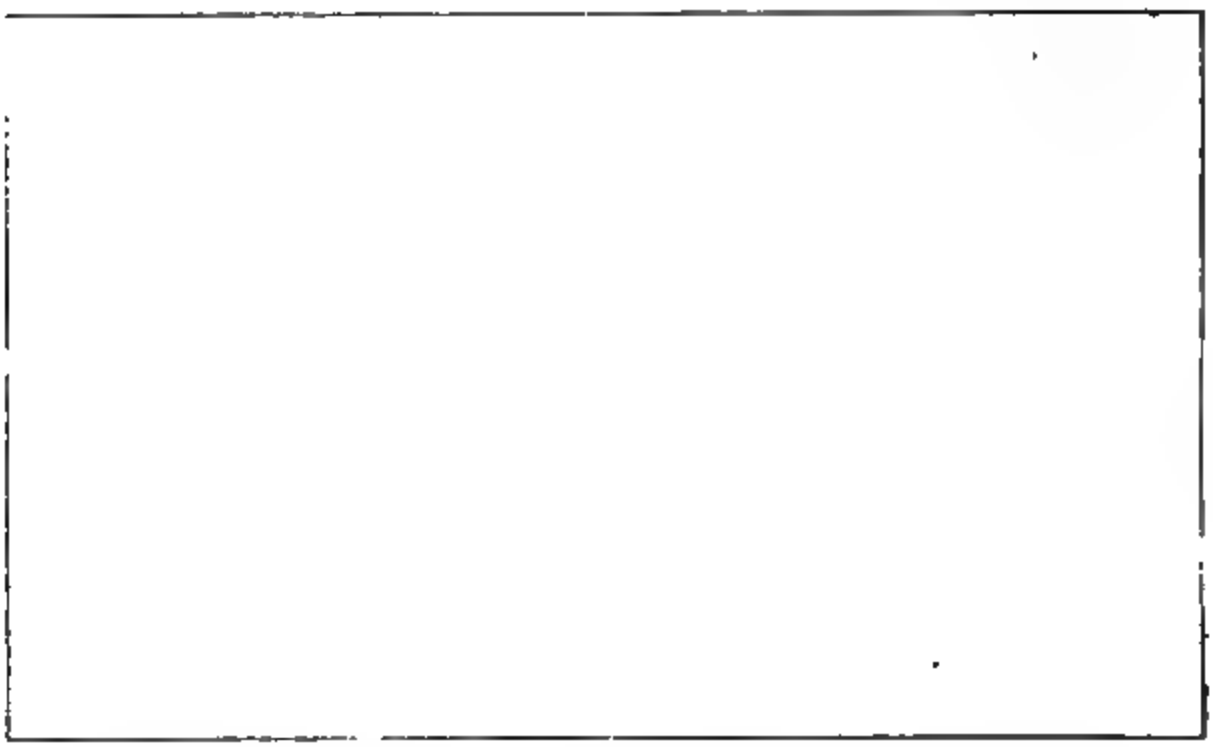


FIG 2--PINTLE LATCH. CASE HARDENED AROUND HOLE GIVING SCLEROSCOPE HARDNESS OF 75 TO 85—FIG. 3—CASE HARDENED GEAR. HARDNESS, 75 TO 85

regular sections and is subject to great stress and wear. In the annealed state some difficulty was experienced because of softness and irregularities in the structure. To properly anneal these castings, a higher temperature is necessary than that used for annealing forgings and bar stock, owing to the castings not having the benefit of the rolling or forging operations. Steel having an average analysis of carbon 0.35 to 0.40 per cent when annealed at 1550 degrees had a tensile strength of 85,000 to 90,000 pounds, a yield point of from 65,000 to 75,000 pounds, an elongation of 18 per cent and a scleroscope hardness of from 25 to 32.

FIG. 7 -CHROME TUNGSTEN CASTING AS RECEIVED FROM FOUNDRY. ×50

FIG. 8—CHROME-TUNGSTEN QUENCHED AT 1550, DRAWN AT 1100 DEGREES, HARDNESS, 45 TO 50

The best properties were obtained by quenching in water at 1500 degrees and drawing at 1050 degrees. Care was observed in quenching as there was some danger of hardening cracks. This was easily controlled by removing the castings from the water while they were still hot (500 to 700 degrees). The amount of distortion was very slight and caused no interference in assembly. The structure after drawing was sorbitic which is tough and strong with an ultimate tensile strength of 115,000; yield point of 80,000; elongation of 12 per cent; and a scleroscope hardness of from 40 to 50.

The castings having from 0.50 to 0.55 carbon were not as

FIG. 9 LOW CARBON CASTING AS RECEIVED FROM FOUNDRY 50 ×

FIG. 10 - LOW CARBON CASTING QUENCHED AT 1600 TO 1625 AND DRAWN AT 1050 DEGREES

FIG. 11—MEDIUM CARBON CASTING DOUBLE ANNEALED, PEARLITE AND FERRITE. SCLEROSCOPE HARDNESS, 25 TO 28

FIG 12—MEDIUM CARBON CASTING QUENCHED AT 1500, AND DRAWN AT 1050 DEGREES. SORBITE AND FERRITE. FROM CASTING SHOWN IN FIG 4

satisfactory as the lower carbon steel. The hardness and strength were good but the scrap was excessive from hardening cracks.

Obtained Good Results With Alloy Steel

Alloy steel castings gave somewhat superior results to the carbon steel The heat treatments were conducted in the same manner but at higher temperatures. The fractures after annealing were much finer and not as crystalline as the carbon castings. The analyses and heat treatment of alloy castings follow:

Chrome-Tungsten		Chrome Vanadium	
Carbon	.43		.22
Manganese	.53		.51
Sulphur	.048		.045
Phosphorus	.037		.042
Chronium	.95		.47
Nickel	Trace		Trace
Vanadium	None		.12
Tungsten	.49		None
Annealed at	1575 to 1625	Annealed to	1625 to 1650
Tensile	110,000		92,000
Yield	85,000		75,000
Elongation	10 per cent		22 per cent
Scleroscope	30		28
Quenched at	1550 degrees	Quenched at	1625 degrees
Draw at	1100 degrees	Draw at	1050 degrees
Tensile	130,000		105,000
Yield Point	112,000		88,000
Elongation	6 per cent		14 per cent
Scleroscope	47		35

FIG. 13. HIGH CARBON CASTING QUENCHED AT 1475 AND DRAWN AT 1050 DEGREES. SORBITE. HARDNESS, 50 TO 60

FIG. 14—MANGANESE STEEL CASTING ANNEALED AT 1950 DEGREES. AUSTENITE. HARDNESS, 35

Manganese steel castings were heated to a temperature of 1900 degrees, and quenched in water. This made them very tough and gave them remarkable wearing qualities. The steel was not machineable after annealing except by grinding. The analysis is as follows: Carbon, 1.25; manganese, 12.50; sulphur, 0.02; phosphorus, 0.08; and silicon, 0.30 per cent. The physical properties after annealing are: Ultimate tensile strength, 108,400 pounds; yield point, 53,396 pounds; elongation, 33 per cent and scleroscope hardness, 35.

Conclusion

In conclusion it can be said that the applications of heat treated castings are practically unlimited. The best results are obtained by first annealing to break up the austenitic and martensitic structure into pearlite and ferrite in order to allow machining, then heating to above the upper critical point and quenching in either oil or water, followed by reheating or drawing to relieve strains and to toughen or give shock-resisting qualities (sorbitic structure).

Case hardening applied to castings the same as to forgings or bar stock gives good results. Annealing of alloy steel castings gives properties that are practically equivalent to heat treated castings. Treated castings replace treated forgings and bar stock in many places. Annealed manganese steel gives a high strength, low yield point and tough wear-resisting properties.

Discussion—Heat Treating Steel Tractor Castings

PROF. A. E. WHITE—Mr. Grotts' paper touches a field which in the past has been approached with much diffidence by manufacturers of steel castings. It is written by one who firmly believes in the practicability of heat treatment of steel castings and who apparently has obtained some excellent results from such treatment.

The writer has maintained for some time that steel casting manufacturers, as a class, have been slow to appreciate the possibilities of heat treatment but he trusts that what he has said in the past has not in any way been interpreted as indicating any doubt with regard to the success of the process when the various conditions surrounding the operation are taken into consideration. He believes that those partially informed with regard to heat treatment may gather from this paper by Mr. Grotts that the heat treatment of castings is a simple operation that can be performed without undue difficulties. No one knows better than Mr. Grotts that the operations he has outlined are not as simply performed as one might gather from a casual reading of the paper.

The writer wishes to emphasize the point raised by Mr. Grotts that higher heats are necessary for the heat treatment of castings than for the heat treatment of rolled or forged material of similar composition. This statement is true with special reference to the first treatment and not to succeeding treatments. It is necessary because the dendritic structure in all cast metal is broken up in rolling and forging and, therefore, the heat treatment necessary for rolled or forged products is not for the removal of dendritic structure. However, in cast materials which have not been rolled or forged, the heat treatment is relied upon to remove the dendritic structure and experience indicates that this removal takes place more readily with a high temperature than with a temperature which is just above the critical range.

Mr. Grotts gives some results on the quenching of steel castings. It is agreed that it is possible to water quench castings; but the possibility of the same cannot be laid down as a general procedure because sad experience would result if water quenching were employed universally. Only parts of great regularity in shape admit of successful water quenching.

It also is agreed that metal can be tempered by removal from the quenching medium when sufficiently hot. This procedure again is dangerous unless it receives the most careful supervision. The writer would not recommend this practice unless careful supervision could be assured.

In all heat treatment work, the rate of heating is almost as important as the rate of cooling. With too rapid a rate of heating, warping and cracks are likely to develop. The writer believes that it will not be many years before the heating up will be done in tunnel furnaces where a gradual rate of heat increase can be obtained easily. In furnaces of the box type, when used for intricate work, it may be found desirable to use two furnaces, one for the primary heating, taking the metal up to about 800 degrees Fahr. and the other for the final heating, taking the metal up to the maximum temperature.

Mr. Grotts gives some interesting results on alloy steel. The writer is firmly convinced of the desirability of using alloy steel in forged and rolled products. However, he questions the advisability of using alloy steel of the type given on page 273 of this paper such as chrome tungsten and chrome vanadium unless there can be absolute assurance of freedom from blow holes and cavities. There is absolutely no reason for using alloy steel for the sake of getting improved physical properties when the presence of cavities and blow holes offset the gain obtained from the use of the alloys.

The writer wishes to suggest one slight correction of technical terms employed by Mr. Grotts. In his conclusions on page 274 he states, "The best results are obtained by first annealing to break up the austenitic and martensitic structure into pearlite and ferrite." In low carbon steels with no special element present, no austenite would be found and probably little tensite. That which might be taken for austenite and mar- of the dendritic structure in the steel.

Electric Heat Treating of Steel Castings

By E. F. Collins, Schenectady, N. Y.

Thousands of tons of steel castings are produced annually for use where particularly severe conditions have to be met. Exhaustive study has been given to the development of alloy steels suitable for parts which must be of light weight and yet must withstand these severe shocks and strains.

In order that steel castings may possess the best physical properties of which the steel is capable, some form of heat treatment is usually required. First, it is here proposed to show the effect of such careful heat treatment on the structure and physical properties of steel castings, and then to call attention to electric resistance furnaces, which possess marked advantages for heat treatment.

Heat Treatment Must Fit Case

High grade steel castings may be no better physically through improper heat treating or no heat treatment at all, than a cheaper and much inferior steel that has been properly heat treated. Structural changes accompanied by varying physical characteristics, due to heat treatment, are governed by definite laws, but it must be recognized that a given heat treatment cannot be applied to all steels with the same satisfactory results; yet a given treatment corresponds to each particular kind of steel, and each responds best to its own particular temperature and time cycle.

Heat treating of steel castings is generally understood to embrace the individual processes of normalizing, annealing, quenching or hardening at high temperature, usually followed by drawing at a lower temperature. One must have knowledge of critical points and transformations occurring, in order to secure the highest physical properties from heat treatment of

Other things being equal, the finer the grain the stronger the steel, and to obtain the refinement the heating and cooling cycle for the steel must be determined as narrowly as possible. It naturally follows that the operator must have facilities which eliminate so far as possible variables in carrying out the process required, if uniformity of product and full worth of the steel is to be secured.

Normalizing Changes Grain Structure

In order to put steel into its best condition for subsequent heat treatments, it is frequently normalized. Normalizing consists in heating steel to well above critical points, and cooling at the proper rate to a temperature below redness. This treatment breaks up networks and large crystals into finer grained structures.

Annealed cast steel parts may be cooled in the furnace in which they were heated or in special cooling devices separate from the furnace.

The purpose of annealing steel castings is to increase softness and ductility and facilitate machining operations; to eliminate existing coarseness of grain and slip bands and secure the desired combination of ductility and elasticity for resisting strains and to relieve internal strains such as may be caused by nonuniform contraction in cooling of the casting in the mold.

The ranges of temperature in annealing shown in Table I are recommended by the American Society for Treating Materials.

Table I

RANGES OF TEMPERATURE IN ANNEALING

Carbon Content Range Per cent.	Annealing Temperature Range Degrees Cent.	Degrees Fahr.
0.00 to 0.12	875 to 925	1607 to 1697
0.12 to 0.29	840 to 870	1544 to 1598
0.30 to 0.49	815 to 840	1499 to 1544
0.50 to 1.00	790 to 815	1454 to 1499

In explanation of two temperatures for the same carbon content it is intended that generally small castings with 0.12

per cent carbon would be treated at 840 degrees Cent. and large castings at 925 degrees Cent.

Crystalline growth and grain size depends on the length of time which steel is subjected to a temperature sufficient to induce change in structure. This time is usually longer in large castings than in small ones.

How Annealing Changes Structure

Figs. 1 to 10 show etchings indicating the change of structure and its progress with time and temperature. The etchings are magnified to 125 diameters. Table II explains the microphotographs of etched steel, from a casting of large size, which was annealed to give proper grain refinement and structure uniformity. One instinctively recognizes from Figs. 1 to 10 that even Fig. 2 shows a structure that is stronger and more elastic than the untreated casting whose structure is shown in Fig. 1.

Table II

EXPLANATION OF ETCHINGS SHOWN IN FIGS. 1 TO 10.

Micro Photo	Time Annealed	Annealing Temp. Deg. Cent.	Carbon Content Per Cent	Remarks
Fig. 1	As Cast			Note large crystals
Fig. 2	5 hours	825		Crystals broken up cleavage slip exists.
Fig. 3	10 hours	825		Structure changing cleavage slip disappearing.
Fig. 4	15 hours	825		Structure changing cleavage slip disappearing.
Fig. 5	20 hours	825		Structure changing cleavage slip disappearing.
Fig. 6	25 hours	825	Approx. 50	Structure changing cleavage slip disappearing.
Fig. 7	30 hours	825		Structure changing cleavage slip disappearing.
Fig. 8	35 hours	825		Structure satisfactory cleavage slip gone.
Fig 9	40 hours	825		Grain size and uniformity satisfactory.
Fig. 10	40 hours	825		
	and 5 hours	950		

Table III is given to show how the physical properties of

a 0.30 per cent cast steel may be changed by heat treatment as follows:

1. No heat treatment, sample as taken from mold.
2. Casting normalized at temperature of 900 degrees Cent.
3. Casting annealed for five hours at 850 degrees Cent.
4. Casting annealed for five hours at 850 degrees Cent. followed by anneal for five hours at 950 degrees Cent.
5. Casting given double heat treatment, that is, first quenched in oil from 850 degrees Cent and then drawn back at 600 degrees Cent.

These results also show conclusively that much advantage may be secured in physical properties of cast steel through proper heat treatment.

Factors Affect Quality of the Product

Factors affecting the uniformity and quality of the product resulting from heat treatment applied to steel castings will now be considered.

1. Structure of cast part to be treated.
2. Carbon content and distribution in steel of phosphorus or other impurities.
3. Physical characteristics called for by specification for the part under treatment.
4. Size and shape of steel castings.
5. Furnace characteristics—design—
   - (a) Furnace atmosphere—full effect.
   - (b) Temperature distribution.
   - (c) Rate of heating and cooling.
   - (d) Capacity of furnace related to time cycle and production.
   - (e) Mechanical handling of furnace charge.
     - (a) Hand.
     - (b) Automatic, that is, conveyor type.
   - (f) Temperature control.
     - (a) Hand control.
     - (b) Automatic control with pyrometer.
   - (g) Method of determining temperature of work.
     - (a) Observation by the eye.
     - (b) Optical pyrometer.
     - (c) Radiation pyrometer.
     - (d) Electric thermo couple and chart record.
   - (h) Heat penetration and absorption.
     - (a) Convected heat.
     - (b) Radiant heat.

(i) Duplication of heating cycle—heating—soaking—cooling.
(j) Amount of scale influencing heating and cooling.

6. Human operation and control of process.
7. Cost overall.

Aside from consideration of quality and uniformity of product, the economic question of overall cost for carrying out the process is obviously important when deciding whether to heat treat or not to heat treat, as well as to select the equipment best suited for special or general work. Each of the foregoing factors are more or less inter-related and each plays a greater or less important part in resulting quality and overall cost. In general, therefore, the overall cost may be expected to be materially reduced in the proportion in which the variables in the process are eliminated by automatic means or definitely controlled by means in the hands of the operator.

Table III

EFFECT OF ANNEALING ON PROPERTIES

Sample	Heat treatment	Temp. of anneal Deg. Cent.	Carbon content	Tensile strength	Yield point	Elon. in 2" %	Red. of Area %
A1	as cast	No anneal	0.30	54,000	20,000	13	20
A3	Normalized	900	0.30	73,000	50,000	28	35
A1	5 hours anneal	850	0.30	73,500	41,000	24	38
A2	5 hours anneal	850	0.30	73,200	43,600	24	34
	5 hours anneal	950					
A2	Oil quenched	850	0.30	85,700	47,700	17	36
	and drawn	600					

Steel castings generally require different temperature and time cycles for their heat treatment than do forgings. Forgings that have been finished at too high a temperature are usually coarse grained, somewhat like castings, whereas if finished at too low a temperature they may be hard and strained. This may be corrected by normalizing or annealing.

In order then to determine the need for annealing or normalizing, it is of first importance that the structure and general nature of the part be known. This also aids in deter-

mining the proper heat treatment to give the desired physical properties.

Determining Nature of Heat Treatment

If the carbon content is very widely different in pieces treated in the same charge, or is not uniformly distributed throughout the single pieces, correspondingly high and low critical points exist. In heat treating a furnace charge, therefore, a compromise must be made between the heat requirements of the high and the low critical points. The critical temperature decreases progressively from about 900 degrees Cent. for 0.0 per cent carbon.

Table IV

COST OF ENERGY IN ELECTRIC FURNACE

Vertical cylindrical electric furnaces rated 400 kilowatts; heating chamber, 6 feet diameter x 25 feet high; power rate, $0.0085 per kilowatt-hour.

	Heating for Quench		
Furnace Charge pounds	Energy kilowatt-hours	Pounds per kilowatt-hour	Temperature of heat treatment degrees Fahr.
21900	1874	11.7	1450
22300	1880	11.8	1450
21700	2088	10.4	1450
65900	5842	11.3	Average

= 32.95 tons.

$$\text{Kilowatt-hours per ton} = \frac{5842}{32.95} = 178 \text{ kilowatt-hours.}$$

5842 kilowatt-hours at $0.0085 = $49.65.

$$\frac{\$49.65}{65900} \text{ or } \frac{49.65}{32.95} = \$1.52 \text{ per ton, for power charge.}$$

Drawing Back

Rate of drawing at 1150 degrees Fahr. = 24 pounds per kilowatt-hour.
Kilowatt-hours per ton at 1150 degrees Fahr. = 84 kilowatt-hours.
Cost per ton at $0.0085 per kilowatt-hour = $0.71.
Cost per ton for the two processes = $1.52 plus $0.71 = $2.23.

If steel with a high carbon content be cooled rapidly, a more tender steel results.

Air cooling may result in some cases in giving a quenching effect to thin sections with a result similar to hardening.

necessary in heating high carbon steels. As an illustration of what radiant heat will do as regards rate of heating, a steel bar, 3 x 3 x 12 inches, may be heated in a 1200 degrees Cent. furnace until it has the same color and temperature as the furnace in the short space of 17 minutes. Examination of the piece shows thorough penetration of heat, without any burning or cracking having occurred at the surface. It is safe to say this could not be duplicated in fuel fired furnaces without very highly heating the outer surface, resulting in burning or fusing and a change of carbon content.

What shall be said further will assume the use of electric furnaces of the resistance or resistor type for heat treating operations. The electric furnace affords a heat treating atmosphere that is free from contaminating gases. Hence its use frees the operator from variation in his work due to absorption of sulphur, phosphorus, etc., from the products of combustion. The temperature distribution may be made entirely uniform in the heating chamber if a properly designed electric furnace is used. The rate of heating and cooling may be controlled absolutely and positively. This control may be made automatic and thus free the operator from any thought of regulating his temperature. The heat cycle once established may be repeated again and again insuring uniform results in product.

The electric furnace may now be had in any size required by production in industrial foundries. Size of furnace does not influence heat control or distribution. Hence a furnace of ample capacity may be had for a given production so that ample time may be taken for the heat cycle, to insure proper heat penetration through the work and satisfactory time for grain change, whatever that may be.

Automatic Accessories for Furnaces

Electric furnaces are available of such design that work may be passed through them by mechanical means, such as conveyor or pusher, as well as car bottom or hand feed furnaces. These conveyors may be automatically equipped to charge and discharge continuously or intermittently. In many cases they are standard conveyors as used in fuel furnaces.

Automatic control and a graphic record of temperature are recommended. This is conveniently accomplished by means of a thermocouple and a controlling-recording instrument, which, when adjusted for the desired temperature, will maintain it indefinitely, and relieve the operator of the responsibility of maintaining furnace temperatures, or will enable one operator to handle a group of furnaces.

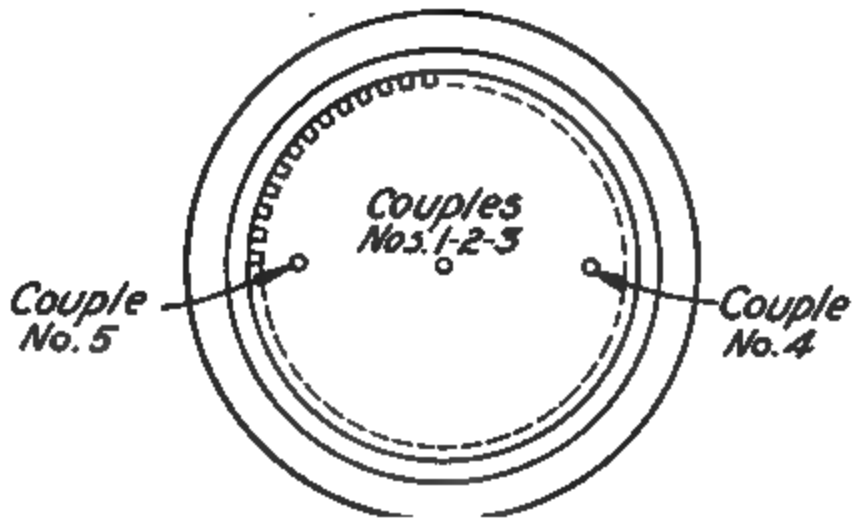
Fig. 11 shows a record of automatic temperature control from an electric furnace, whose regulator has been set to heat a charge to 1500 degrees Fahr. Shortly after 11 a. m. the cold charge was placed in the furnace. The upper line of the record is the resistor temperature, i. e., the source of electric heat and the lower line is the temperature on the surface of the charge. The temperature of the charge increased as did also the resistor, until the surface reached the desired temperature (1500 degrees Fahr.) at 4 p. m. Here the temperature of the source was automatically controlled so that heat was fed to the charge to compensate for the heat equalization going on within the charge. At about 4:40 p. m. this equalization of temperature within the charge was complete, as indicated on chart, when upper and lower record lines became parallel.

Hence automatically the charge was heated to a uniform temperature throughout, without allowing the surface of the charge to rise above the desired temperature, 1500 degrees Fahr. In other words, the charge was uniformly heated irrespective of its size or shape, and without danger of overheating in any way.

The electric furnace offers a radiant heat of uniform intensity, in an unmuffled heating chamber. The unmuffled electric furnace lends itself to almost perfect delivery of heat from the source of heat to the work, and makes for a perfect heat control by automatic means promoting uniform and rapid heating of charge.

As had already been implied, the characteristics of the electric furnace are such that they may be made almost entirely automatic. This means an exact duplication of heating and cooling cycles. Therefore when once established

TEST DATA SHOWING HEAT UNIFORMITY OF ELECTRIC FURNACE



TIME	THERMOCOUPLES-TEMP °C					AVERAGE TEMP.	PRESENT DEVIATION FROM AVERAGE	
	1	2	3	4	5		ABOVE	BELOW
30	25	25	25	25	25	25	0	0
30	527	537	532	530	545	534	2.07	1.31
30	670	679	671	666	669	669	1.5	.45
30	777	783	776	766	780	776	1.0	1.3
30	858	864	857	849	864	860	.46	1.3
30	860	865	862	862	863	862	.35	.23
30	928	934	930	930	928	930	.43	.21
30	933	932	927	925	927	929	.64	.43
30	950	950	952	952	955	952	.31	.21

FIG. 16—TEST DATA SHOWING HEAT UNIFORMITY OF ELECTRIC FURNACE

given heat treatment can be again and again applied, with complete assurance that uniform work will result.

Fig. 12 shows a car bottom furnace used for annealing steel castings and Fig. 13 shows three of a battery of four vertical furnaces. The fourth furnace is beyond the quenching tank. These furnaces were used in heat treating gun forgings and gave interesting results, tabulated in Table IV, which shows the actual cost for energy in furnaces of moderate size.

The overall cost for the month of October, 1918, for day and night operation, without shutdown of any kind was $2.76 per ton. This was just before the armistice, when production was at the maximum rate. This economy is very high, but it could be realized in almost any moderate-sized plant, if well designed and continuously operated. It costs money to shut down any furnace and heat it up again, and the electric furace is no exception in this respect.

Advantages of Automatic Control

One reason for high economy is the fact that automatic control prevents waste of heat, by not allowing the charge or furnace walls to become heated to a higher temperature than necessary. This is a very large factor, because at such temperatures additional temperature is gained only at progressively higher cost per degree.

Fig. 14 shows a record taken from an ordinary annealing furnace in which the air temperature was held at 1400 degrees Fahr. The absolutely constant temperature, controlled within narrow limits is desirable. Fig. 15 shows an automatic control board for one of the vertical furnaces. The control instruments are mounted on the sub-bases of the panels.

Reference has been made to the uniform temperature distribution in these furnaces. Tests were made by heating a vertical cylindrical furnace from cold to 950 degrees Cent., in which thermocouples were distributed as shown in Fig. 16. The data are also tabulated in Fig. 16, and show that the distribution is almost perfect.

In conclusion, it may be said that upon the furnace

depends to a very great extent, the success of the heat treatment. Hence a furnace type and design which follows as closely to the ideal requirements for the process as does the electric resistance furnace deserves the closest study by those concerned with this class of work.

Discussion

MR. JONES.—I would like to ask Mr. Collins whether these figures of $2.76 a ton are for annealing or for quenching and drawing? There is a statement made in the paragraph "for annealing," and afterward a statement "for quenching and drawing."

MR. E. F. COLLINS.—Those figures were for quenching and drawing.

MR. JONES.—It seems to me that if the cost for quenching and drawing is only $2.76 a ton, certainly that would mean the cost for annealing should not be any more, or perhaps it would be less.

MR. E. F. COLLINS.—It would be less.

MR. A. W. LORENZ.—I am representing a firm which manufactures a chrome steel casting for its own use. We find that it pays us in the matter of improved product to heat treat not all of our castings, but certain castings, such as pinions, rollers, etc., which go under some of our heavy machines. We obtain quite an improvement, and to a certain extent even in the weakest part of the casting. There is always some improvement. Of course, the weakest part of the casting will not approach by any means the strength which the same heat treatment would give to a forging, but at least there will be an improvement, and we have found that that improvement is worth while.

MR. R. B. FARQUHAR.—I would like to ask whether this cost involves intermittent or rather continuous operation.

MR. E. F. COLLINS.—Continuous operation.

MR. R. B. FARQUHAR.—Of course the radiation would be very decidedly affected by intermittent or continuous.

MR. E. F. COLLINS.—This was continuous, 24-hour a day operation.

MR. R. B. FARQUHAR.—It would be interesting to know what the difference in that cost would be if this furnace was used in the average foundry, perhaps where it might be running one heat a day in the cost that you give.

MR. E. F. COLLINS.-- I could say roughly in obtaining efficiency on the 10-hour day basis that you can figure on the average an 80 per cent efficiency in the electric furnace, and through that means get its efficiency on any length of day. The electric furnace, as well as any other, improves in efficiency with load, its maximum efficiency being accomplished when you have the heating chamber practically filled with a charge. That is the one way in which the electric furnace has the advantage over fuel fired units. With a full charge at all times, you get an efficiency on the average of about 80 to 85 per cent.

PRESIDENT KOCH.—It is not assumed that the cost for refractories and the cost for replacing is going to be very much less in the electric furnace than it is on our other fuel furnaces?

MR. E. F. COLLINS.—It should be. There is absolutely no wear on the refractories in the electric furnace, running at these temperatures, except the abrasion on floors, and that sort of thing. So far as the walls of the furnace proper are concerned, there is no wear or tear going on, as there is where you have the impinging of the gases, as in the ordinary fuel fired furnace.

Annealing Steel With Pulverized Coal

By C. H. Gale, Pittsburgh

The use of pulverized coal in the foundry has been the subject of many articles in recent years, and the annealing of steel castings has had its share of attention of those interested in the industry. It is not the intention to enter into a discussion of the merits of either phase of foundry practice, but simply to give the results of annealing steel castings with pulverized coal.

For a number of years, steel castings in the foundry where these investigations were conducted had been annealed with natural gas or oil. After the installation of a pulverized coal plant and the use of this coal for annealing had begun, a marked difference in the physical characteristics of the steel was noticed, the tensile strength being greater with the elongation and reduction in area and the results of the bend tests less than had formerly been obtained from heats of the same analysis and annealing temperature. No other condition being in evidence which would cause this change, attention was directed to the fuel used and after an extended investigation it was discovered that the carbon and sulphur content was considerably increased when using coal as fuel, the average analysis for a number of heats being: Carbon, before annealing, 0.262 per cent; after annealing, 0.287 per cent. Sulphur, before annealing, 0.043 per cent; after annealing, 0.052 per cent.

Coal High in Sulphur

The coal used was high in sulphur, ranging from 2.45 to 2.80 per cent. In order to ascertain the effect of repeated anneals on the carbon and sulphur content of the steel, test pieces were subjected to three anneals, the analysis before and after each anneal being as follows:

FIG. 1—INCREASE OF CARBON CONTENT IN STEEL ANNEALED BY PULVERIZED COAL

FIG. 2—INCREASE OF SULPHUR CONTENT IN STEEL ANNEALED BY PULVERIZED COAL

	Before Annealing	After 1st Anneal	2nd Anneal	3rd Anneal
Carbon	.262	.287	.310	.330
	.259	.283	.308	.320
	.272	.294	.317	.329
	.267	.299	.324	.325
Average	.265	.291	.317	.326
Sulphur	.043	.052	.055	.056
	.044	.054	.056	.057
	.041	.050	.054	.055
	.042	.052	.055	.055
Average	.0425	.052	.055	.056

By referring to Figs. 1 and 2 it will be noted that these elements, particularly sulphur, took a rapid increase at the first anneal. The increase at the second anneal was considerably less while the gain after the third anneal was negligible, indicating that the metal had at the second anneal absorbed about all of these elements it could from the fuel.

The thought having occurred that possibly the fuel had a case hardening effect upon the steel, test bars 1½ inches square were made and from these drillings were taken ⅛, ¼, ½ and ¾ inch from the surface for analysis with the following average results:

Carbon	⅛ in.	¼ in.	½ in.	¾ in.
Before annealing...	.286	.284	.285	.285
After first anneal..	.298	.293	.288	.285
After second anneal	.301	.299	.295	.295
After third anneal.	.308	.302	.299	.296
Sulphur				
Before annealing...	.046	.046	.046	.045
After first anneal..	.055	.052	.049	.047
After second anneal	.064	.058	.052	.048
After third anneal.	.065	.059	.055	.051

As will be seen by the results given above, and as shown in Fig. 4, the increase in sulphur was less the farther below the surface the sample was taken, and that the same applied to the carbon, Fig. 3, but not to such a pronounced degree. In other words, the increase in both sulphur and carbon is considerable near the surface, but decreases as the depth below the surface increases.

In order to secure more data on the absorption of sulphur

FIG. 3—CARBON CONTENT AT VARIOUS DEPTHS AFTER ANNEALING WITH POWDERED COAL

FIG. 4—SULPHUR CONTENT AT VARIOUS DEPTHS AFTER ANNEALING WITH POWDERED COAL

when annealing with this fuel, particularly when the sulphur content of the coal was high, test bars of malleable iron were broken in two pieces, one piece being annealed with natural gas and the other piece annealed with .pulverized coal with the following average result:

	Per Cent
Before annealing, sulphur.....	.044
Annealed with gas, sulphur.....	.044
Annealed with coal, sulphur.....	.051

As there is a loss of carbon in the annealing of malleable iron and the percentage of this loss is not constant, no determinations for carbon were made.

Discussion—Annealing Steel with Pulverized Coal

A MEMBER.—I would like to ask how the sulphur was determined in the last table? Was the volumetric test used?

MR. C. H. GALE.—It was determined by the volumetric test.

MR. F. G. ALLISON.—Do you not think that the method of putting the coal and the air into the furnace would have a great deal to do with the type of combustion chamber?

MR. C. H. GALE.— Yes, it would; that would make quite a difference. In this case we have no combustion chamber whatever. The coal is blown directly into the furnace and the metal being annealed has all the chance in the world to absorb anything that may be in the coal.

MR. RALPH WEST.—I would like to ask about what percentage of increase in tensile strength was found due to this method of treatment?

MR. C. H. GALE.—We are making just an ordinary commercial low carbon steel. Our tensile strength had always been running about 65,000 to 70,000 pounds per square inch. When I noticed this change in it, it ran up to 80,000, 82,000, 85,000 and 88,000. After these investigations, when I determined in my own mind the cause of the change and went back to annealing with natural gas or oil, it dropped again down to the 65,000 or 70,000.

MR. F. G. ALLISON.—It would seem from your analyses that the effect is more or less of a surface effect. In machining down the test bars you cut the surface away and yet you found the tensile test effect within, or toward the center of the piece. It seems strange that the tensile test is not really definitely correlated to the increase in sulphur.

MR. C. H. GALE.—No, it is not. You will notice in the paper the sulphur and carbon contents vary as the drill pene-

trated the steel. The test bar, of course, would have all that outer metal removed so that the test piece as actually pulled would have a much lower carbon and sulphur content than the surface of the metal would.

PRESIDENT C. S. KOCH.—It might be interesting, therefore to know the size of the original test bar that you turned down to probably 0.505 inch.

MR. C. H. GALE.—The test bars are about 1 1/8. They vary from that to 1¼ square. Then we turn them down to 0.505 so you can see that what was left in that 0.505 was the part of the bar that had the least sulphur and carbon.

Fractures and Microstructures of American Malleable Cast Iron

By W. R. Bean, H. W. Highriter and E. S. Davenport,
Naugatuck, Conn.

In taking up a discussion of this subject it is our purpos to explain in a way that will be clear to the practical foundry man, the causes of various fractures of malleable cast iron tha occur in regular operating routine, such explanations as we hav to offer being in the light of information obtained throug close chemical, microscopic and mechanical examination. Fc the purpose of illustrating the various points discussed, photc micrographs made from specimens which are typical of th various microstructures and fractures are shown.

The majority of the micrographs have been taken at a mag nification of 100 diameters except where other magnificatior have been desirable to bring out the structure.

The White Iron Structure

The normal white iron structure needs no detailed discu sion other than to say that the fracture of average sized cas ings should be a clear white, free from graphitic carbon spo and flaky or spangly in appearance, as contrasted with a hig iron fracture which is fine grained and granular. Castings c highest quality can be obtained only where the white iron free from what we call "primary graphite." The presence these graphite plates results in a weakness and brittlene approaching these qualities in gray cast iron as the amou of primary graphite increases from the point where the fra ture shows a few black spots to the point where the fractu is entirely gray.

On the other hand if the hard iron fracture is granul in appearance it is a clear indication of high iron in whi case a normal annealing treatment generally will not produ high grade black heart malleable cast iron.

Fig. 1 shows the microstructure of normal white or ha iron. The dark constituent is pearlite, the white constitue

All are familiar with the typical fracture of American malleable cast iron which is distinctive from the fracture of any other ferrous metal. The malleable cast iron which is produced in this country is commonly termed "black heart" as distinguished from European or white heart malleable, since the fracture is black or very dark gray in appearance, the outer portion of the section being slightly lighter in color as a result of decarburization. Iron of high quality and high ductility will show in fracture a silky or velvety sheen changing with the direction of the light.

For the purpose of comparison and contrast, we are including here micrographs of other common ferrous metals with brief descriptions as follows:

Fig. 4 indicates clearly the way in which the continuity of gray cast iron is interrupted by the plate-like crystals of primary graphite which separate out upon the cooling of the iron from the molten condition. This difference between primary graphite and temper carbon accounts in large measure for the relative weakness and brittleness of gray cast iron.

Wrought Iron

Fig. 5 shows a specimen (transverse section) taken from a bar of commercial wrought iron of the following composition: Silicon, 0.013; manganese, 0.30; sulphur, 0.073; phosphorus, 0.155, and total carbon, 0.27 per cent. Four specimens turned to the dimensions of the A. S. T. M. standard malleable test bar showed an average tensile strength of 49,520 pounds per square inch and an elongation in 2 inches of 27.6 per cent. The micro structure here is quite similar to that of normal malleable cast iron, the ground mass being a matrix of ferrite throughout which are scattered inclusions of slag, these corresponding somewhat to the nuclei of temper carbon in annealed malleable cast iron.

Armco Iron

Fig. 6 indicates the microstructure of Armco iron, which is generally considered to be the nearest in chemical composition to pure iron of all commercial products. Its comparative purity is brought out by the analysis of this specimen which is silicon, 0.07; manganese, 0.08; sulphur, 0.065; phosphorus,

FIG. 8—X 100

FIG 9—X 100

0.004, and total carbon, 0.10 per cent. Four tensile test specimens turned to the dimensions of the A. S. T. M. standard malleable test bar showed an average tensile strength of 44,890 pounds per square inch and an elongation in 2 inches of 46.4 per cent.

The matrix or ground mass in this case is also ferrite in which the majority of the impurities are present in solid solution, the remainder being present in the form of minute inclusions which show up as small black spots.

Low Carbon Steel

Fig. 7 is taken from a specimen of commercial low carbon or mild steel, the composition of which is silicon, 0.06; manganese, 0.57; sulphur, 0.086; phosphorus, 0.009; and total carbon,-0.16 per cent. Tensile test bars finished as in the two previous cases showed an average tensile strength of 62,100 pounds per square inch and an elongation in 2 inches of 39.5 per cent. A comparison of this micrograph with Fig. 33 which is taken from a ⅛-inch section of American malleable cast iron is of interest because of the similarity in grain size and in general appearance, although in Fig. 7 the dark spots are pearlite whereas in Fig. 33 the dark portions are temper carbon.

A comparison of the physical properties of malleable cast iron with wrought iron, ingot iron and commercial rolled bar steel brings out the facts that the tensile strength of malleable cast iron is well above that of either wrought iron or ingot iron and only slightly under that of annealed rolled steel. While the elongation of malleable cast iron is not as high as of the other three materials, it is nevertheless high for a cast product.

Abnormal Fractures from Insufficient Annealing

Turning now to some of the abnormal fractures and structures which are found in malleable cast iron, we have in Fig. 8 a clear case of insufficient or underannealing. The composition is in every respect normal: Silicon, 1.03; manganese, 0.35; sulphur, 0.090; phosphorus, 0.202, and total carbon, 2.56 per cent. The white constituent is pro-eutectic cementite, the gray is pearlite and the black spots temper carbon, these latter indicating that annealing has started but has not progressed to

The time has been in years past, when phosphorus was one of, if not the worst bug-bear, to the average malleable foundryman of all of the elements in malleable cast iron, but we now know that many things have been laid at the door of phosphorus which belonged elsewhere. Professor Touceda in his paper "Some Remarks Regarding the Permissible Phosphorus Limit in Malleable Iron Castings," read before this association at the 1915 meeting, did much to dispell the illusions which had previously persisted and we will refer only briefly to the effect of phosphorus on fracture and microstructure.

The result of high phosphorus content upon the fracture of malleable cast iron is shown by specimen *B*, Fig. 12, the fracture being white, although not brilliant, tending toward light gray. The composition of this was silicon, 1.20; manganese, 0.31; sulphur, 0.052; phosphorus, 0.320; and total carbon, 2.50 per cent. The tensile test bar showed an ultimate strength of 57,658 pounds per square inch, and an elongation in 2 inches of 8 per cent, which is somewhat higher in tensile strength and lower in elongation than would be expected if the phosphorus were normal.

Fig. 15 shows the microstructure of the cross-section of a tensile bar of the same composition as specimen *B*, Fig. 12. The microstructure is practically normal, the only abnormality being in the somewhat larger grain size and the appearance of polygonal crystals, conditions which are probably caused by the high phosphorus content. The white fracture is very likely the result of an embrittling effect produced by solution in the iron of iron phosphide, this embrittling being evident from the above physical properties.

Fig. 16, taken from a specimen analyzing 0.27 per cent phosphorus which, however, was badly burned in the anneal, shows the eutectic of iron and iron phosphide. This eutectic appeared only in the center of the bar and is unquestionably due to segregation, caused probably by the unusual annealing conditions, raising the content of phosphorus in this portion of the specimen considerably above 0.27 per cent. The statement has been made by some that this eutectic of iron and iron phosphide makes its appearance when the phosphorus is in excess of 0.25

per cent, but Figs. 15 and 16 seem to indicate strongly that this is not necessarily the case, annealing conditions playing an important part.

So far as we have been able to determine, phosphorus exerts little or no influence upon the condition of the carbon.

Abnormal Fractures From Too Rapid Cooling During Annealing

We find from experience that white rims may be divided into two fairly distinct classifications. The first, referred to in connection with Fig. 11, is designated as a "composition rim," which is the direct outcome of abnormal chemical composition, resulting in the production of relatively stable pearlite. This rim is distinguishable in rectangular sections by the fact that it is very clearly and sharply defined and the further fact that it is of uniform depth, following very closely the outlines of the casting. This is illustrated by specimen *E*, in Fig. 12.

The other classification we designate as "annealing" or "cooling" rim. It is the result also of the presence of pearlite although in this case the pearlite may not necessarily be stable. In a rectangular section this rim may be distinguished from the composition rim by the fact that the rim is not quite so clearly defined and does not follow so closely the outline of the casting, but is deeper at the corners, resulting in a dark center of oval shape. A typical case is shown by specimen *F*, Fig. 12.

Fig. 17 shows such a cooling rim, the microstructure of which we have termed "bull's eye," which while pearlitic, as are the structures in Figs. 11, 13 and 14, is not necessarily stable and under some conditions can be completely removed by reannealing or by a simple heat treatment in which the specimens are raised to a temperature of approximately 1500 degrees Fahr., or in excess of the critical point and permitted to cool at a rate not to exceed 8 degrees per hour. In this micrograph (Fig. 17) the upper portion is toward the outside of the casting, the lower portion toward the center. Throughout the micrograph will be noted areas near the center of which are black spots of temper carbon. In the upper left hand corner appears a mass of pearlite, shown at higher magnification in Fig. 18, at the center of which is a temper carbon nucleus surrounded by

a ferrite sphere. These two latter are the result of graphitization. The iron carbide of the pearlite has broken down into its constituents, iron and carbon, the former passing to the ferrite matrix and the latter to the temper carbon nucleus.

A careful study of the conditions under which this specimen was produced points very strongly to rapid cooling during anneal as the cause, the rate of cooling at the critical point being so high as to arrest the graphitization in that portion of the casting where decarburization had already rendered graphitization somewhat difficult. The composition of this specimen is in every respect normal, as in fact have been the analyses of the majority of the specimens of this nature which have come to our attention. Such a condition as this, however, will be aggravated in a specimen, the analysis of which is tending toward abnormality.

Fig. 19 gives another example at relatively high magnification of the bull's eye structure resulting in part, we believe, from rapid cooling and in part from a composition somewhat difficult to graphitize, this being silicon, 0.65; manganese, 0.27; sulphur, 0.080; and total carbon, 2 23 per cent. High temperature may also have been a factor, the fracture being somewhat similar to specimen *C*, Fig. 12, although not so brilliant as this. The pearlite in Fig. 19 is coarser than in Fig. 18, although in this it does not show up clearly since the pearlite in the latter was etched for contrast and subsequent polishing removed this particular point which prevents our showing a better micrograph.

The statement has been made above that this form of pearlite can under certain conditions be eliminated and a normal structure and fracture produced by a simple treatment. Specimens *F* and *G* in Fig. 12 represent one instance of this change and *H* and *I* another instance, the former pair representing the change from a heavy white rim to a normal fracture, the latter from white to normal fracture. Such white as is present in the reannealed specimens is due to compression in breaking. Where an abnormal fracture results from this condition, pearlite of the bull's eye character is found only in the outer rim, at least in sections of ⅜-inch or larger. The fracture may be, however,

Fig. 24 is from the same iron, silicon, 0.75; manganese, 0.28; sulphur, 0.062; and total carbon before annealing, 2.43 per cent; after annealing, 0.92 per cent. The fracture is extremely brilliant and shows large crystals. The microstructure consists of very coarse pearlite throughout. The carbon content in this specimen after annealing is very close to that of a eutectoid steel which is from 0.85 to 0.90 per cent carbon. The composition of this specimen is given to show that there is nothing in the iron which would prevent annealing to a normal black fracture.

White Rims from Nitrogen

It is suggested by some that white rims may occasionally be produced by the absorption of nitrogen from that which surrounds the castings in the annealing ovens. To check this hypothesis a careful experiment was carried out on two specimens, one being an annealed sample and the other a white iron. In both cases a white rim was produced by annealing in an atmosphere of ammonia, given the usual cycle of temperature and time. Microstructure of this rim is indicated by Fig. 25, which shows clearly the needles of iron nitride which are typical of nitrogenized iron but which indicates the complete absence of any pearlite. Fig. 26 represents the central portion of these specimens, the ferrite grains being deeply pitted but without any nitride needles.

This experiment would seem to indicate quite definitely that a white rim can be produced by the absorption of nitrogen but indicates further that such a rim is not pearlitic and furthermore that the production of a rim from this source does not occur in general practice, since a structure similar to that shown in Fig. 25 where there are crystals of iron nitride, has, we believe, never been found in a regularly annealed specimen.

White Fracture From Galvanizing

Another source of concern to the casting producer and more so to the casting user is the white fracture which sometimes results from the treatment of malleable castings by the hot dip galvanizing process. Such a case is illustrated by speci-

men *D*, Fig. 12. This fracture, while tending to whiteness, is more nearly gray than specimen *B*, the high phosphorus sample, and is frequently designated as a "mixed fracture."

A larger number of specimens have been examined very carefully under the microscope without as yet having discovered any definite change in microstructure accompanying the presence of such a white fracture.

Micrograph of a galvanized specimen which possessed normal fracture before galvanizing but a white fracture after galvanizing is shown in Fig. 27. From all appearances the microstructure of this specimen is identical with that of normal annealed malleable cast iron.

White Fracture From Quenching

A white fracture can be produced and cases are on record where such fractures have been produced as the result of incomplete knowledge on the part of the casting user of the composition of malleable cast iron, and the result which will occur if castings are quenched or rapidly cooled from temperatures above the critical point. Such fractures are very fine, close grained and white, although not brilliant, this fracture being approximated more nearly by specimen *A*, Fig. 12, than by any of the other white fractures shown.

Fig. 28 shows the structure resulting from quenching a normally annealed malleable casting. The structure is probably martensitic, which accounts for the extreme hardness and brittleness of castings which have been so treated.

White Heart Malleable Cast Iron

We cannot leave the subject of white fractures without touching upon white heart or European malleable cast iron and while the specimen which we have was produced in America, the structure is somewhat similar to that of the European product. Fig. 29 is from a specimen of annealed white heart malleable of the following composition: Silicon, 0.96; manganese, 0.07; sulphur, 0.040; phosphorus, 0.050; combined carbon, 0.49; graphitic carbon, 1.41; and total carbon, 1.90 per cent. The constituents are pearlite, ferrite and temper carbon with possibly a small amount of free cementite.

In composition this specimen, we believe, differs from

FIG. 31—X 82

FIG. 32—X 50

European white heart malleable principally in the manganese and sulphur contents. These, however, are sufficiently unbalanced to prevent complete graphitization in annealing, which, coupled with a high temperature or long anneal, is sufficient to produce a white heart malleable.

Structurally, white heart malleable differs from American black heart malleable chiefly in the fact that the former is largely pearlitic as contrasted with the black heart structure of ferrite and temper carbon. Chemically, the difference lies principally in the fact that some of the elements, silicon, manganese, sulphur and carbon, one or a combination or all, are so thrown out of balance as to prevent complete graphitization of the carbon content.

Primary Graphitization

Occasionally there is found what is termed a "low" fracture, which, however, seldom occurs in other than a heavy section, and whenever this fracture is found silicon and total carbon are high. Such a fracture is difficult to reproduce but may be identified by a dove colored rim or in some cases a cloudy appearance containing this and other colors.

Fig. 30 shows the structure of such a specimen which is somewhat similar to Fig. 4 from a gray cast iron specimen. This micrograph is from a heavy section containing silicon, 1.01 and total carbon, 2.78 per cent, the carbon determination having been made after the casting was annealed. In all probability the carbon content of the hard iron was considerably in excess of 3 per cent.

Fig. 31 shows primary graphitization in a more incipient stage than that shown by Fig. 30. This specimen is also from a heavy section, containing silicon, 1.35, and total carbon, after annealing, 2.50 per cent; probably 2.80 per cent or over in the hard iron casting.

The dendritic formation or more or less connected carbon areas represent what was a gray spot in the white iron casting. The fracture of the casting from which the micrograph was made very clearly showed this to be the case.

Such a structure as this is highly detrimental to strength

tionably to be preferred to one having most of the links of high strength, but with dangerously weak links at critical points. Shrinks are these weak links.

Relation Between Thickness of Section and Grain Size

Figs. 33, 34 and 35 represent the microstructures at equal magnifications of ⅛-inch, ¼-inch and ½-inch sections respectively of a standard test wedge, the purpose of these being to indicate the variation in grain size that accompanies these thicknesses of section, the smaller the section the smaller being the size of grain and also of carbon spots. These three micrographs bring out the fact that, assuming identical annealing conditions, a casting of thin section will have a proportionately finer grain than a casting of heavier section and identical chemical composition. A comparison may be made between Fig. 35 and Fig. 3, which latter was taken from a ⅝-inch diameter tensile test bar showing a tensile strength of 56,500 pounds per square inch and an elongation in 2 inches of 18 per cent. Although the grain size of a specimen of medium section, ½-inch or greater, is comparatively large, the physical properties as illustrated by above tensile bar are good, and it may be reasonable to assume that if there could be a change in the heavier sections to a microstructure such as that corresponding to Fig. 34, more improved physical properties would result.

Unusual Variation in Annealing of Small Castings

As an illustration of the delicate balance which is sometimes obtained of the various factors which influence the microstructure and physical properties of malleable cast iron and as an indication of the probable existence of certain factors of which we at the present time know very little, we submit Figs. 36, 37 and 38, which show the difference in microstructure at three very closely situated points in a light section casting, shown at actual size in Fig. 40.

The fracture at point No. 1 was normal or essentially so, the structure being represented by Fig. 36. The fracture at point No. 2 is abnormal, although approaching normal as shown by Fig. 37. The fracture at point No. 3 was white and structure abnormal, the micrograph being very similar to Fig. 1 showing an unannealed specimen. The first assumption was

Owing to the nature of the paper and the necessarily large number of subjects discussed, it has been impossible to treat the majority of them with the completeness which their importance to the malleable industry deserves. Furthermore, while the temptation has been strong, we have in all but a few cases refrained from going into detailed technical discussions of points which are still open to question. We have attempted to keep in mind always the original purpose of speaking to practical foundrymen, and such metallographic terms as appear have been used with the idea of explanation to those not familiar with their use.

Report of A. F. A. Committee on Specifications for Malleable Castings

This committee, which was appointed to co-operate with that of the A. S. T. M. committee on specifications for malleable iron castings, has nothing of interest to report for the past year. No meetings have been held by it for the reason that no suggestions have been brought to its attention that necessitated its deliberation. There seems to be a general agreement that to date the present specification fills the needs of the user with satisfaction, although an attempt was made at the committee meeting of the A. S. T. M. to lower the ultimate strength by several thousand pounds. This suggestion was not approved.

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The Triplex Process for Making Electric Furnace Malleable

By H. A. SCHWARTZ, Cleveland.

Some eight or ten years ago the National Malleable Castings Co. became interested in the use of electric furnaces. Naturally the original field of investigation was in the manufacture of steel castings, and the work was conducted at the Sharon plant of the company.

Preliminary experiments at Sharon having demonstrated the probable usefulness of the electric furnace in the metallurgy of malleable cast iron, an experimental plant was later installed at the company's Grant works at Chicago for the further development of this application on a semimanufacturing scale.

A very considerable amount of development work was required to overcome various commercial and metallurgical difficulties encountered, but a process soon was developed for supplementing the electric furnace with various auxiliaries and producing a high grade product under commercial conditions. The process as covered by various patents of its inventor, W. G. Kranz, vice president of manufacture of the National company, has now been in commercial operation for some years and very large tonnages of electric furnace malleable have been made and sold.

Under ordinary conditions the Grant works makes only electric furnace malleable, although the old air furnace equipment still is available in case of emergency. The company's new Woodhill road plant in Cleveland is equipped entirely for melting by the electric furnace.

On account of the commercial importance of the tonnages of malleable iron now produced by this method it may not be inopportune to place on record a brief description of the metallurgical principles upon which the operation of the Kranz triplex process depends.

chemical composition and more particularly is nearly always relatively high in carbon content. For the oxidation of carbon and, by inference, of silicon and manganese also, the most economical available procedure is the bessemer process.

The cupola and the bessemer converter therefore are admirably adapted to work in conjunction with the electric furnace and to supplement its shortcomings. The cupola furnishes cheaply a supply of molten iron of only approximately controlled chemical composition and of a higher carbon content than is desired in the product.

Furnace Receives Cupola and Converter Metal

The bessemer converter readily decarbonizes iron converting it into molten steel. The electric furnace can very efficiently take as its charge a mixture of molten cupola iron and molten bessemer steel and finish this charge by additional heating and by the elimination of oxygen and sulphur. This combination of operations constitutes in general the triplex process.

The equipment for the commercial operation of the process consists of a cupola of sufficient size to supply continuously molten iron at the rate required by the electric furnaces. Working in conjunction with the cupola is a side-blown converter of such capacity as to be capable of decarbonizing a sufficient proportion of the cupola output to reduce the carbon content of the mixture of cupola metal and bessemer converter metal to the desired figure. These two units together serve the electric furnace.

In both plants the electric furnaces are of the Heroult type operated at approximately 100 volts on 3-phase alternating current. In addition to the metallurgical units referred to, it must be understood that suitable cranes, electric regulators, and other auxiliary equipment are also required.

A clearer understanding of the metallurgical fundamentals of the process probably will be obtained by a step-by-step discussion of the functions and operations of the three separate stages in the melting operation. Let us assume to begin with that it is desired to produce as the final product of the melting

than in the final product while remaining high enough to permit of satisfactory cupola and converter operations.

The carbon and sulphur content is immaterial. As a matter of fact, no consideration need be given to the manganese in practice, although too high a manganese value in the cupola metal would be a disadvantage. In actual operation these requirements are met by limiting the cupola stock to materials none of which are higher in phosphorus than the resulting malleable to be made.

Generally the melting material is sprue, malleable scrap, steel scrap and high silicon pig iron in such relative proportions as to give to the mix as charged an average silicon content of 1 per cent or a very little over. This silicon content in the mix produces a molten metal of a silicon content about 0.85 per cent, which is quite suitable to the execution of the further steps in the process.

As already stated the manganese, carbon and sulphur content of the mix is unimportant, although in mixes made of the material mentioned the manganese will be about 0.25 to 0.30 as charged and the carbon about 2.50 to 2.70 per cent.

During the melting operation the metal always loses manganese and silicon and gains sulphur. It may gain or lose carbon depending upon the carbon content of the original charge and the melting condition in the cupola. As a matter of fact the carbon content of the molten iron is but little affected by the carbon content of the material charge, and greatly affected by the temperature and depth of the incandescent bed of coke over which the iron passes after it is melted.

Analysis of Cupola Product

It has been found by experience that under the operating conditions usually existing the carbon content of the cupola metal ranges from about 2.75 to about 3.25 and averages slightly over 3 per cent. A mix such as that quoted above, therefore, will result in molten metal having a chemical composition of carbon, about 3.00; silicon, 0.85; manganese, 0.14; sulphur, [illegible] phosphorus under 0.20 per cent. We have,

furnace. The resulting mixture by calculation should chemical composition: Carbon, 2.50; silicon, 0.71; m 0.11; sulphur, 0.13; and phosphorus, under 0.20.

This composition is correct for carbon and ph The silicon and manganese are too low and the sulph high. At this stage of the process a sample is taken alysis and the further operation conducted in accorda the result of that analysis.

Laboratory Analysis Determines Procedure

The laboratory makes determinations of carbon, manganese and phosphorus. It is not intended that and last of these elements should require any further Sulphur determinations are not made since this element further acted upon during the progress of the electric o

The furnace itself is basic lined and the atmosph nearly neutral. Of its own accord, therefore, it woul little or no change in the chemical composition of the ir tained in it. For the purpose of removing oxygen and a slag is formed upon the surface of the metal by t in lime, fluor spar and crushed coke. Calcium carbide is in the slag by the reaction of the coke and lime.

As long as any oxygen or metallic oxides remain metal the calcium carbide is oxidized as rapidly as for the expense of the oxygen of the bath. When this pletely gone, a reaction between the lime of the slag a sulphur of the metal begins and goes on during the prog the heat.

The degree of desulphurization obtained depends u time and temperature. It has been possible to reduce t phur to abnormally low amounts; sometimes down to 0 cent. This has no commercial advantage and some di tages, and in practice the attempt is made to stop the des zation at approximately 0.04 per cent. While the desul ing has been going on the laboratory report has come

cedure differs in no essentials from that of ordinary malleable practice, except, of course, that it is not usual with any other method of melting to handle the metal into the foundry in 6-ton crane ladles.

Summing up the three stages of the process again it will be seen that the cupola has acted merely as a melting medium; the bessemer converter has served to adjust the carbon content of the metal; and the electric furnace has deoxidized and desulphurized the product and furnished also an opportunity for the exact adjustment of the final composition.

Electric Furnace Product Easily Controlled

It will be noted also that the electric furnace does not pretend to make a product differing in any chemical respects from that obtained as the result of good air furnace practice. The electric furnace can make a much wider range of material than can the air furnace. Indeed it could be operated to make material of almost any analysis which could be written down. As a matter of fact its superiority in the malleable industry arises not in that it makes a product essentially of a new character, but rather in that it permits of very closely regulating the uniformity of the material which is turned out. From the standpoint of accuracy of control, the operation is infinitely superior to the very best possible air furnace operation.

Continuous Operation is Essential

The general application of electric furnace metal in the industry is limited by a number of considerations; even aside from the patent protection involved. To be economical an electric furnace must be kept in reasonably continuous operation. This necessitates a 24-hour operation during the entire week. Further, there is a minimum size of furnace below which operation is no longer either practical or economical. These two considerations limit the application of the method to plants producing considerable tonnages.

the operations just described. Therefore, the process could scarcely be carried out in an already established works.

The significance of this statement can be realized from the fact that both of the electric melting plants operate in buildings especially designed for the purpose and radically different in construction from those generally found in the malleable industry.

No attempt has been made in this paper to enter into the relative merits of electric and air furnace malleable, nor has the writer believed it to be his duty to enter upon a detailed consideration of the manner and cost of electric furnace operation.

Discussion

MR. FRANK HODSON:—Mr. Schwartz' paper presents a clear and lucid account of the process in use at the plant of the National Malleable Casting Co., utilizing electric furnaces for the production of high grade malleable iron. As this is probably the only plant in America where this has been done for some time on a commercial scale, it is to be hoped his paper will be given the attention it deserves by all malleable iron manufacturers.

Of course the process of treating hot metal from cupolas, blast furnaces, bessemer and open-hearth furnaces in the electric furnace is not new, having been tried and used in many modifications in France, Germany and England for the last 15 years. The method described by Mr. Schwartz is, however, new in America and is one that will open up a very big field for the electric furnace; Mr. Krantz is certainly to be congratulated on having the courage of his convictions in putting down and operating a large plant on this process.

Mr. Schwartz very properly emphasized the necessity of a specially designed shop equipped for quick handling of the

hot metal, radically different from the usual malleable plant and continuous operation of the electric furnaces. It is interesting to note that both six and 15-ton electric furnaces are being used, and an expression of opinion as to the best size of furnace for this kind of work would help others considering similar installations.

It may be of interest to know that the British steel firm, Vickers, Ltd., is interested in the installation of a large plant at the Parkgate Iron & Steel Co., for making cheap shipplate steel. The process in this case consists in taking hot metal from a blast furnace into a metal mixer, from there to a bessemer converter and finishing off in 10-ton Greaves-Etchells electric furnaces. It is believed this will make cheaper steel than is possible by any present process, and the operation is a very quick one from hot pig iron to finished high grade cheap steel.

The advantages of the electric furnace malleable are set out very modestly, and I think all members of the association would welcome an additional paper by Mr. Schwartz giving comparative costs, tests, operation and relative merit of the electric furnace as against air furnace malleable.

Progress in Manufactur Malleable Iron

By Enrique Touceda, Albany, N. Y

Few if any consumers of malleable iron castings fact that within recent years there has been a ma provement not only in the physical properties of the but particularly in its uniformity. Assuming that t is conceded, let us analyze briefly the present situatic view of determining the prospect for a further bette process and product, and make inquiry as to how f tivities may best be directed to bring about this result

In the manufacture of malleable iron, the metallu paratus consists of melting furnaces and annealing ove usually were built by men who had but little knov calorics and who were further handicapped by ignc to the chemical reactions that were taking place durin and annealing. Inasmuch as the first reverberatories t for the manufacture of wrought iron, it was but nat their design would be closely copied. It is gratifyin that the camelback and other freak construction inheri this source has almost entirely disappeared.

Air Furnace Thermal Efficiency

Let us inquire what recent changes in design ha plished toward the cheapening and betterment of the In regard to the former it hardly can be claimed that nace thermal efficiency has been bettered except in a n gree. Those who are familiar with this furnace mus that in its present type it is of necessity so very of heat that without certain modifications to which shortly refer, little more can be done to improve its e In the best designed air furnaces now in operation t not exceed 10 per cent. If the British thermal unit valu coal per pound is 14,000, then 90 per cent of the hea

in part through radiation, but to a much greater extent up the stack. Therefore of the 14,000 British thermal units, only 1400 are doing useful work.

The foregoing does not mean that no substantial benefit has resulted from the improvements that have been made in air furnace construction, because such is not the case. However, these improvements have operated to make for greater certainty in uniformity of composition of the hard iron from heat to heat, rather than in a saving of coal. Much progress has been made in this particular and it is certain that this attainment is preeminently of much greater importance than a saving in coal, because of all desiderata the uniformity of the product stands first. It can be stated therefore that an improvement in product certainly has resulted from such changes as have been advocated and put into effect in later air furnace designs.

Is there any hope that the efficiency of the air furnace burning coal on a grate can be improved by, say, 50 to 100 per cent, or the control perfected to a point that will facilitate a still greater uniformity of product than is possible in present day practice?

Proportioning Air Supply

One of the shortcomings of the air furnace is the proportioning of the secondary air supply admitted through correctly inclined tuyeres that protrude through the furnace roof at a short distance in front of the bridge wall, in such amount as will provide for the proper combustion of the volatile combustible of the coal. It is manifest that if there is a certain amount of combustible passing over the bridge at a particular interval of time there should be admitted only the number of pounds of oxygen that will just completely unite with this combustible, no more and no less. If too little air is admitted, combustion will not be complete and fuel will be wasted, while if too much is admitted, the condition will be increasingly bad in proportion to the amount of air in excess of that necessary to secure complete combustion.

In practice the overhead blast is adjusted to deliver a constant quantity of air, and it is clear that when the stoker

shovels in coal to renew the fire the volatile combusti off with such rapidity that if the air supply is just to take care of this amount it would be but an inst it would be so greatly in excess of requirements that point on the condition would continually grow worse t was repeated. An investigation of this matter thr determinations on various furnaces disclosed the fac CO_2 was frequently as low at 9 per cent when it sh been near to 19 per cent. Consequently, due to the tunate conditions, the air supply is adjusted in such or should be, that on firing there is a strong reduc and at the time when firing is to be repeated the amo is not too greatly in excess. If this indicates anyth it shows that firing should take place at very short in time when obviously the adjustment of the secondary can be more accurately gaged.

It also indicates that it is highly desirable that n means be devised to deliver a constant small suppl to the fire pot, in which event it would be possible closely adjust the air supply in theoretical proportion bustion. Thus far efforts in this direction have n fruitful.

The foregoing state of affairs is exaggerated in t naces in which a thin bed of fuel is used, a condition general some few years ago, barring a few exceptio fronted with these facts the author, in the air furnac he has made, always has arranged for a deep bed o order to convert as much of the fixed carbon on t to CO, a combustible gas to the end that this would and make more constant the amount of combustible ing over the bridge in any interval of time between and the next. This allows not only a more proper a of the secondary air supply, but also makes possible t tion of considerable of the fixed carbon in the heart than in the fire pot where it does infinitely less good. tempt has been made by the author to see if it woul practical to set up a CO_2 recording instrument clos furnace, connected by an electrical device with the d

the overhead blast pipe in such a manner that the damper could be functioned by the movement of the recorder. This proved impractical because of the impossibility of securing a recorder with quick enough action. That is, the results shown on the instrument at any instant corresponded to conditions existing some four minutes previously, which obviously made this attempt at control impractical. The writer believes that there is little hope of improvement in fuel efficiency, unless some one devises a practical mechanical stoker, makes use of powdered coal, or resorts to some of the schemes of which mention will be made. The author does not believe that any attempt yet made to construct a gas producer integral with the furnace has proved a success.

Intermittent Operation Is Factor

One reason why gas producers integral with the furnace have not been more generally adopted is the fact that inasmuch as the furnaces are run intermittently, and it is essential that the producer have a very deep bed of fuel, too much unconsumed coal must be left in the fire pot at the end of the heat. Aside from this, steam is not used under the grate and in consequence the gas is very lean. If the furnace were worked continuously the story might be brighter in the case of those furnaces in which this principle has been employed.

Moreover, the designs are faulty, for the producer end of the proposition has been practically such in name only. The author believes that in a properly designed furnace of this type, a fuel ratio equal to or in excess of that at present attained through the use of powdered coal is possible, provided two heats per day are run. While this may seem attractive, it should appeal only to small plants that would not be justified in installing a powdered coal equipment, in spite of the fact that the installation cost would be divided between the annealing ovens and the melting furnaces. It seems more than probable that as soon as certain improvements in the adaptation of powdered coal to air furnace work have been made, this fuel will prove most promising for use in this type fur-

nace, due to the high fuel ratio possible, coupled with tractive features of less manual labor and better co control.

In 1906 the writer was granted a basic patent (Metallurgy No. 823560") on what he deemed was proved type of air furnace, from the operation of whic quite confidently expected a saving in fuel and partic more perfect control, could be expected.

Use of Waste Heat Boilers

Waste heat boilers have been used for years in co with puddling and air furnaces. In such cases, howe steam has been used in steam engines for the oper various kinds of machines. When waste heat is utilized manner a saving in coal is affected, but while this is true not add to the efficiency of the furnace, for the latte signed to melt iron and not to run machinery. If, howe steam from the boiler is used in a steam turbine gear generator, and the current from the generator run to el that protrude through the sides or roof of the furnace, fire-brick electrodes at high temperature, one in conta the bath at each end of the hearth, then the waste heat converted by this means into heat within the furnace, w course, will increase the furnace efficiency directly as the of heat absorbed. Not only would this be accomplish much more important still the scheme admits of a mucl furnace control than is possible in ordinary air furnace v almost any degree of super-heat can be obtained in an ex short interval of time and at the exact moment it is ne

In a fair-sized plant where numerous furnaces are at the same time, steam could be used from the was boiler of one furnace to augment that generated in the lar one from which a heat is about to be tapped, mak scheme elastic and adding to the amount of current pos obtain in any interval of time. This scheme would ope should, to also shorten the heat and make possible the ing of a greater number of heats from one furnace.

Some seven years ago the author designed a two reverberatory furnace, after Pietzke, the substructure of

rested on a standard railway turntable center, in order that it could be made to revolve between a fire pot and stack that were permanently fixed. In operation a charge is placed in both hearths. As the gases pass over the charge in the hearth next to the fire pot, they must of necessity go through the second hearth before they can reach the stack. By the time the charge in the hearth No. 1 is ready to be tapped, it is expected that the charge in hearth No. 2 will have been melted. Instead, however, of tapping the heat that is ready while the furnace is in its original position, it is first revolved, for not only can it be as successfully tapped when next to the stack but this procedure results in allowing the partly finished heat in the other hearth to receive the maximum temperature of the fire pot at the earliest possible moment. A charging platform of proper inclination and height and of a capacity sufficient to hold an entire charge is conveniently located at one side in such a position as to enable the furnace when revolved to register with it. In this manner a charge can be slid into a hearth within a few minutes, this being facilitated through the raising of a hinged section of the roof and the special construction of the platform. The same principle can be utilized in other forms of construction, as the rear hearth can be at a higher level than the one in front of it, and the molten metal which it contains can be allowed to flow by gravity through tap holes connecting the two hearths. This scheme would do away with the necessity of revolving the furnace, but the charging would have to be done in the usual way.

Design of Double-Hearth Furnace

The author also drew up designs for a double-hearth with a common side wall, the fire pot being located between the separate flues of a stack that met in one flue above the fire pot. In this case the furnace would have to rest on a track, in order that the two hearths alternately could register with the fire pot and one leg of the stack, while the other stack leg was closed by a damper.

The writer has thought of one other way in which it might prove practical to make use of the waste heat from the air furnace, which has to do with the reactions that take place

between steam and incandescent carbon. In the operat gas producer, the amount of steam that is possible t order to enrich the gas to the fullest practical extent is for if an attempt is made to use an excess, the fire cooled to a point that will prevent the desired reactic taking place. When dry steam comes in contact witl at a red heat, or over the temperature that this signif decomposed into two combustible gases, viz., carbon n and hydrogen. These gases are unaccompanied by ine gen so that the full caloric value of the gases can be The importance of this will be appreciated when it that the average nitrogen content of producer gas is a per cent.

If therefore, the space between the rear bridge v the stack of an air furnace be arranged so that a layer protected by a thin gas-tight brick covering, can be con inserted and the ash withdrawn, or some other arrangen ployed that will perform the same service, steam g from a waste heat boiler can be passed through th descent coke and the gases withdrawn at the other side by pipes to the front end of the hearth at each side wh would be consumed. A charge of one ton of coke would cient for quite a number of heats, for the reason t amount of coke would yield about 120,000 cubic feet having a B. t. u. value of about 617 per cubic foot. Assum the coal used in air furnaces runs 13,575 B. t. u's. per one pound of coal will be equivalent to 22 cubic feet or the 120,000 cubic feet will equal 2.75 tons.

While the efficiency of the open-hearth furnace tically double that of the air furnace it is questionable melting can be done for half the cost if the latter is by the former. Where natural gas or coke oven gas i able this can certainly be approximated, and to a lesser with oil, but if a gas producer installation is necessary, terest on the investment, operation and maintenanc will represent such a substantial figure that the propositi not look as inviting as it might appear at first sight, part

as the open-hearth furnace itself costs something over $1000 per ton of capacity.

It is not believed that any worth while improvements have been made in open-hearth furnace construction used in the malleable iron industry. Is there a chance? The author believes this possible. The Blaw-Knox Co., Pittsburgh, has control of a device developed by Mr. McKune of the Steel Co. of Canada, the object of which is not only to produce a bunsen burner effect at the port, but it enables the ports to be so adjusted that they can best be proportioned for burning the fuel and allowing the products of combustion easy passage to the stack. The installation of such a device in present furnaces would result in both economy and better control. Both economy and uniformity would result if instead of melting the cold charge in the open-hearth furnace, it were melted in a cupola adjacent to the furnace and either allowed to run down the spout and into the hearth by gravity, or the molten metal introduced into the hearth by means of a transfer ladle, thereby increasing the furnace capacity, and reducing melting costs, etc. The author has made this suggestion many times in the past, but it does not seem to have been attractive to those whose plants would easily admit of this method of procedure. A melting ratio as high as 10 to 1 could be obtained in the cupola for the reason that the molten metal would not have to be given more superheat than is sufficient to enable it to easily run down the cupola spout or pour from a transfer ladle without serious skull. The sole reason why cupola malleable is not the equal of the air furnace or open-hearth product lies in the fact that inasmuch as it is melted in the presence of carbon, it is unavoidably much too high in that element to produce a superior product. If it were possible to control the carbon content in cupola hard iron, this product would equal that made in any other type of apparatus. There seems to be a fear on the part of many that cupola metal also would be too high in sulphur. It is not difficult to make gray iron castings in which the sulphur does not exceed 0.070 per cent. There are plants where the sulphur content is at times as low at 0.055 per cent. In either the air or open-hearth furnace, a much greate-

percentage of the silicon, carbon and manganese is
while the charge is being melted than subsequently take
In other words, if a normal oxidation of the impurities
during the melting of the charge, there is little lial
trouble from this time to the end of the heat. The
believes that a more uniform melting is possible in the
than in the air or open-hearth furnace, for the control is
No trouble is experienced in obtaining a cupola product
a carbon content of 3.00 per cent and if just previous to
the molten metal from the cupola is run into the hearth
furnace, sufficient steel is charged into the hearth to lo
total carbon by a proper amount, no trouble should be
ienced in connection with this proposition.

The use of the Stoughton oil-fired cupola would enal
the sulphur and carbon to come under better cont
this would be the logical cupola to use. Some plants
many as six open-hearth furnaces and melt a large daily

Use of Coke Oven Gas

Taking into consideration the high cost of fuel
fact that the price of natural gas is constantly soaring,
with the cost of installation of producers, etc., it is prac
such plants to lower the fuel cost through the installatic
number of small by-product coke units, provided they a
locality where the sale of the coke and other by-products
The gas could be used in the open-hearth furnaces and
ing ovens, as well as for running a gas engine to g
electricity for power and light, and if necessary, for
purposes. Certain companies make a business of sell
various by-products on a commission basis.

Probably the greatest advance toward improvem
product chargeable to change in apparatus has been n
the case of the annealing oven construction and contr
this particular, and this actually is the heart of the p
great strides have been made within the past few years
long ago conditions in the annealing department could n
have been worse. This statement is not too sweeping t
almost every principle was violated. Those concerns
ovens were under pyrometric control could be counted

fingers of one hand; now the number who are not thus equipped, at least among the numerous concerns with whom the writer is acquainted, could be counted in the same manner. An understanding of the reactions that take place during the anneal illustrated the absolute necessity for positive control at temperature as well as during cooling. Four years ago few if any ovens were insulated; today practically all new ones are so thoroughly insulated that a person can hold his hand on the outside plates without discomfort. While this obviously makes for fuel economy, the more important matter is uniformity of temperature throughout all parts of the oven. Greater care is being exercised in damper and ash pit door construction and freedom from leakage throughout, in order that the cooling down from temperature can be gaged with nicety.

The sloping roof has made possible the avoidance of excessive heat at the bridge wall, and has resulted in an evening up of the heat at the front end of the oven. The building of the ovens in single units, with the stacks or stacks on the inside has not only served to cheapen construction, but obviously has permitted the oven to be brought to temperature more quickly. This also serves to greatly lessen the smoke nuisance. The solid floor has replaced the complicated and costly underfloor flues. It now is the general practice to have but two short underground flues, one at each side of the oven, leading to the stack.

In the author's latest design, in which he has used a gas producer fire-pot integral with the oven, a sloping roof over the oven proper and stacks within the oven, there are no underground flues whatever. The two main side flues which carry the products of combustion to the stack are built on top of the oven side walls where they may be easily inspected at any moment.

Opportunities for Young Men

Discussing the problems of plant organization, it can be stated that a betterment of the product, particularly in regard to uniformity, can in part be credited to the changes that have taken place in personnel. It is inevitable that the young must in the natural course of events succeed the old, but in this ca

the industry has profited to a much greater extent tha narily would be understood through this platidinous st for the improvement has not resulted so much through creased energy and enthusiasm of youth as it has to t that these men have entered the game fortified by the t fundamentals which the older men lacked. Just how im this scheme of procedure appears to the American M Castings Association can be illustrated by the followin

"This association has decided to establish a Bur Inspection, the object in part being in the nature of a gu to the purchaser that the castings of the membership wi every way as represented by their test bar reports an claims in general, but equally important it is proposed t men selected as inspectors shall possess a technical educat that they show promise of executive ability in order th become logical candidates for vacancies at the various Before starting in on their work the men must take a preli course in the metallurgy of malleable iron in the author's tories, and a subsequent course in inspection at a number plants in order that they will be competent from the star

The author feels confident that future advancement industry must come in large measure through improvem metallurgical apparatus. An attempt has been made in this to show that creditable progress already has been made has been indicated that further developments are mor possible of attainment. This paper was written wi idea of stimulating interest and inspiring activity in th ticular direction.

Bright Future Awaits Malleable Industry

The rationale of the process has been pretty well v out and such matters are pretty well in hand for the black type of product, but caution must be exercised if future de ments give promise of a modification of this type of produ the one vital thing to keep in mind at all times is the ma machinability. It is in this particular that malleable iron and no change in character of product will be able to su fully replace the other, whose characteristics operate to i in the least this valuable and unique property.

What, then, are the possibilities for the near future? Possibly the following simile will answer this question: When a juggler starts to learn his tricks, he begins with simple stunts which he awkwardly muffs and fumbles until through lengthy practice he masters the first one. He practices first with two balls, then with three, and then four and finally he finds that he can use six with as much ease and accuracy as two. We are in his position exactly. We started with low ultimate strength and elongation, made many muffs as we raised the standard. Some weeks ago we received a standard tensile test bar among other excellent ones, that showed over 60,000 pounds ultimate strength and 33.5 per cent elongation. This means that while we can now juggle four balls at the present time with great accuracy and do fairly well with five, we can only do the six-ball trick on extremely rare occasions. We have proved however that the trick is possible of accomplishment and if it can be done once, it can be done practically all the time, although only at the cost of patience and practice. When this time comes double your capacity, for there will be an unlimited demand for a guaranteed product of such strength and ductility.

Discussion

A MEMBER.—Recently I encountered some iron with a sulphur content of 0.14. I was immediately alarmed and held that heat of iron and tested samples. We are making pipe fittings, in which we do not require strength necessary in ordinary mercantile iron. I put the samples through and they came out in fine shape. I accordingly sent them to the tamping room. Of course I did not mention the fact that I was experimenting. Since there was no complaint, I thought possibly the chemist might have made some mistake. I obtained another sample of that heat of iron and sent it through, saying nothing to the chemist and again the iron showed 0.14 sulphur. I account for it by the fact that our manager had a chance to

pick up 500 tons of high sulphur iron running up as 0.07 and 0.08 and some as high as 0.09. He asked could use it and I said I could, by using it with low iron. So he bought it. At the same time we wer to use any coal we could get.

A MEMBER.—Some of the best malleable iron I l seen has been as high as 0.11 per cent in sulphur. I reports from different fittings companies throughout t try of analyses of their iron and one report that I indicated that the company was making iron with as high as 0.14 per cent.

PROF. ENRIQUE TOUCEDA.—I do not like to sulphur above one-tenth. Usually if it is as high a makes the iron very sensitive to heat and has flame tendencies. You have a better chance than any other would, because your fittings are thin.

MR. WALTER JEFFERY.—What percentage of m should be carried in the case of high sulphur?

PROF. ENRIQUE TOUCEDA.— With a 0.14 sulphu we would want the manganese around 0.28 to 0.31 that is, in hard iron.

Fuel and Combustion

By Max Sklovsky, Moline, Ill.

When it is stated that out of a total of 600,000,000 tons of coal mined per year, 150,000,000 tons can be saved, it may not appear to have a bearing on the malleable business. However, viewing it simply as a transportation problem in which one-third of the railroad rolling stock of the country is used for hauling coal and by-products, it becomes at once a transportation problem of moment. It takes over a million cars in service to transport coal and if one-third of the coal can be saved, the railroad difficulties will be materially lessened. About 500,000 workers are engaged in the coal fields of the country. There are as many more men engaged in the transportation and utilization of the fuel all over the country. By

FIG. 1—COAL PRODUCTION IN MILLION TONS

FIG. 2 COAL DISTRIBUTION AND EFFICIENCY OF UTIL

a reduction in the use of 25 per cent of fuel, there c release of about 200,000 workers in the production a portation and utilization. It is obvious that the tr waste in fuel is having a decided effect upon the situation of the country.

Fuel Difficulties Are Increasing

Purely as a general business problem, the coal question is of interest and importance. From the stan the malleable iron industry, it is several times more im not only because fuel enters in as a large element in

but also because of the selection of kinds and the manner of using the fuel bears a vital relation to the success of making malleable iron.

Fig. 1 shows the production of coal in the United States during the last 80 years. In 1835, a comparatively small

FIG. 3—FUEL ECONOMY OF METALLURGICAL OPERATIONS

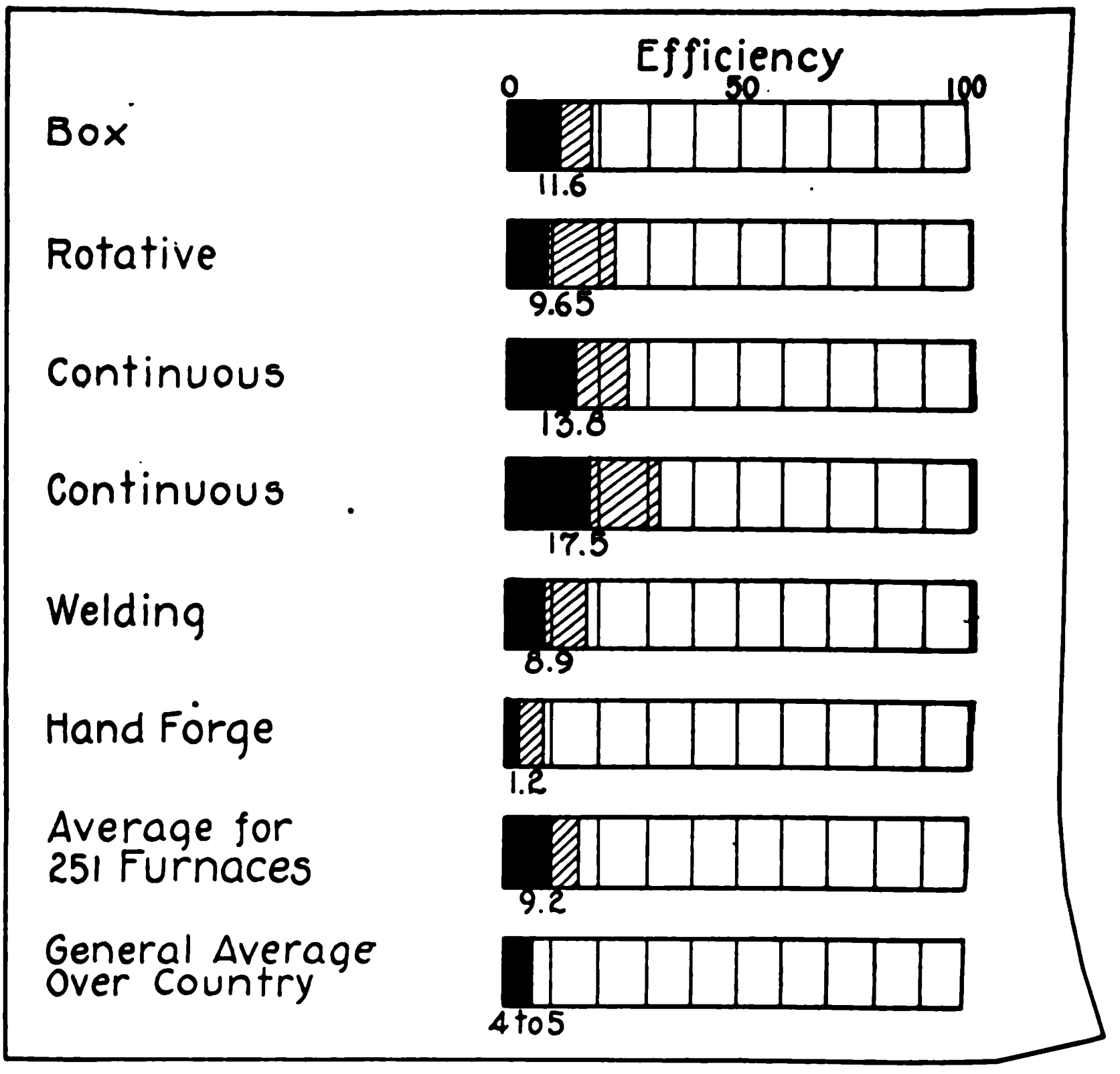


FIG. 4 EFFICIENCY OF OIL-FIRED FURNACES

quantity of coal was produced, that is, about 20,000,000 tons. Coal production has been going on on a rapidly increasing scale until in the last two years the production has been at the rate of about 600,000,000 tons per year. If this ratio is permitted to continue, the difficulties and cost of obtaining fuel also will increase. Likewise the increasing cost of coal will have a direct bearing on the cost of other fuels, such as petroleum oil and its products.

Fig. 2 indicates the four different divisions in which fuel is used, particularly coal. These four divisions are very nearly equally divided, each using about 150,000,000 tons of coal annually. The total energy of the fuel is indicated by the ex-

terior outline and the shaded section of each division indicates the energy effectively utilized. It shows plainly that we are only utilizing effectively 10 per cent of the energy contained in the coal, the balance being wasted. In other words, we are 10 per cent efficient in the utilization of fuel products and are throwing away 90 per cent of the fuel produced. Were it possible to obtain a utilization of 20 per cent in place of 10 per cent, the fuel production could be cut down from 600,000,000 to 300,000,000 tons per year. An increase in efficiency from an average of 10 per cent to an average of 13 per cent would decrease the coal consumption 150,000,000 tons per year or one-fourth of the total. Judging from the data presented, it is obvious that a reduction in production of 25 per cent is a practical proposition. Each industry must solve its own problems in its own way.

Waste is Accumulative

Great gains have been made in the utilization of coal and other fuel in the production of power. Power is today produced with substantially one-half the coal consumption with which it was produced 20 years ago. A substantial gain has been made in the utilization of fuel in transportation, although avoidable waste still is very great. It takes from 10 to 20 per cent of the coal mined to transport it to the final point of consumption. The waste in fuel is therefore accumulative. Shipping coal long distances or re-shipping coal as is sometimes the practice is obviously a waste of the worst character. Gains have been made in some of the branches of the metallurgical industries.

Fig. 3 indicates a partial classification by groups, showing the efficiencies obtained ordinarily in various metallurgical industries using either coal, coke or liquid fuel. It will be seen from this chart that in the process of malleable melting where the difficulties are not as great as in open-hearth steel furnaces, the results from fuel are decidedly unfavorable by comparison. Particularly unsatisfactory are the fuel results obtained in malleable annealing process. In the forging industry where the fuel results, on the whole, are the lowest, there have been

strides made in recent years which bid to more than double the present results. While the present average shows only about 4 per cent, recent developments indicate in many applications results ranging from 30 to 40 per cent, and therefore a rise to 8 or 10 per cent on the average is not an unreasonable expectation.

Fig 4 shows what has been accomplished in one plant where fuel oil has been used as the chief heating medium. This chart indicates various types of heating furnaces with decidedly different results. The dark shaded portion indicates the parts of energy of the fuel utilized; the white portion or balance shows the lost energy in each case. The light shaded portion shows the increment or gain in efficiency made after a serious effort had been applied toward the saving of fuel which in this group has been somewhat over 30 per cent.

How Gains Can Be Made

There are two distinct ways in which gains may be made One is by greater efficiency in combustion and the second b

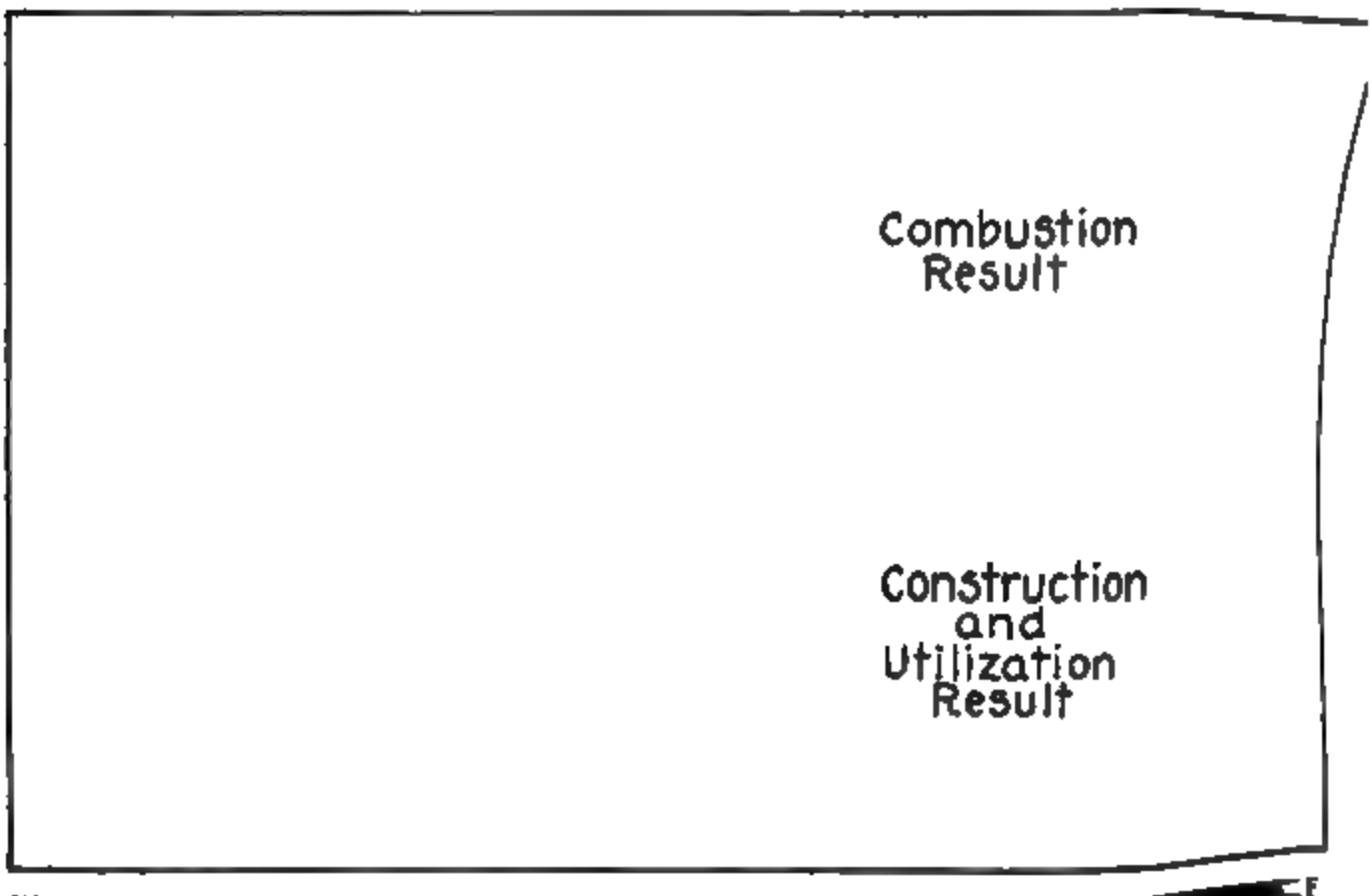


FIG. 5—FUEL CONSUMPTION IN OIL-FIRED FURNACES UNDER D FERENT OPERATING CONDITIONS

6—RELATION OF FURNACE TEMPERATURE TO CAPACITY

greater efficiency in utilization. These are distinct as gathered from some of the charts that follow. Fig. 5 ill the distinction between the method of burning fuel and tion of the resultant heat. The upper block of the diagram indicates the amount of fuel used per hour bef improvements were made. The block immediately be dicates the fuel used after the method of combusti changed without changing the method of utilization. Th and fourth blocks below show the gain made by better tion of the heat produced in which both better furna struction as well as pre-heating of the stock were ir The top figure of 11.3 gallons per hour shows a fi duction of 4.1 gallons per hour. Fig. 6 is a graphic st of the results of a number of tests from which the rule transmission was derived and in which the relation l temperature and capacity is indicated. It shows in how the utilization principle operates in heating device instance, metal can be heated to 1500 degrees, that is, t nary red, in 12 minutes in a furnace temperature of 1(grees. In a furnace temperature of 2700 degrees the t heating is reduced to 1.2 minutes or one-tenth of the tim indicates plainly that the higher the furnace or com temperature obtainable, the more readily the heat en utilized.

Fig. 7 shows how by better combustion methods, better utilized in a manner that is a distinct revelation is in contrast with Fig. 6, and shows that higher tempe which are necessary for better utilization of heat ener not necessarily obtained at the expense of the great waste. On the contrary, higher fuel temperatures can tained with a reduced, rather than an increased, amc fuel. In this particular instance this was accomplis the control of the proper ratios of fuel and air. The fo charts are presented to emphasize the seriousness of fue lems, the need for better utilization of fuel, and to po what has been done in other than foundry industries better utilization of fuel. Fuel is utilized in the mallea

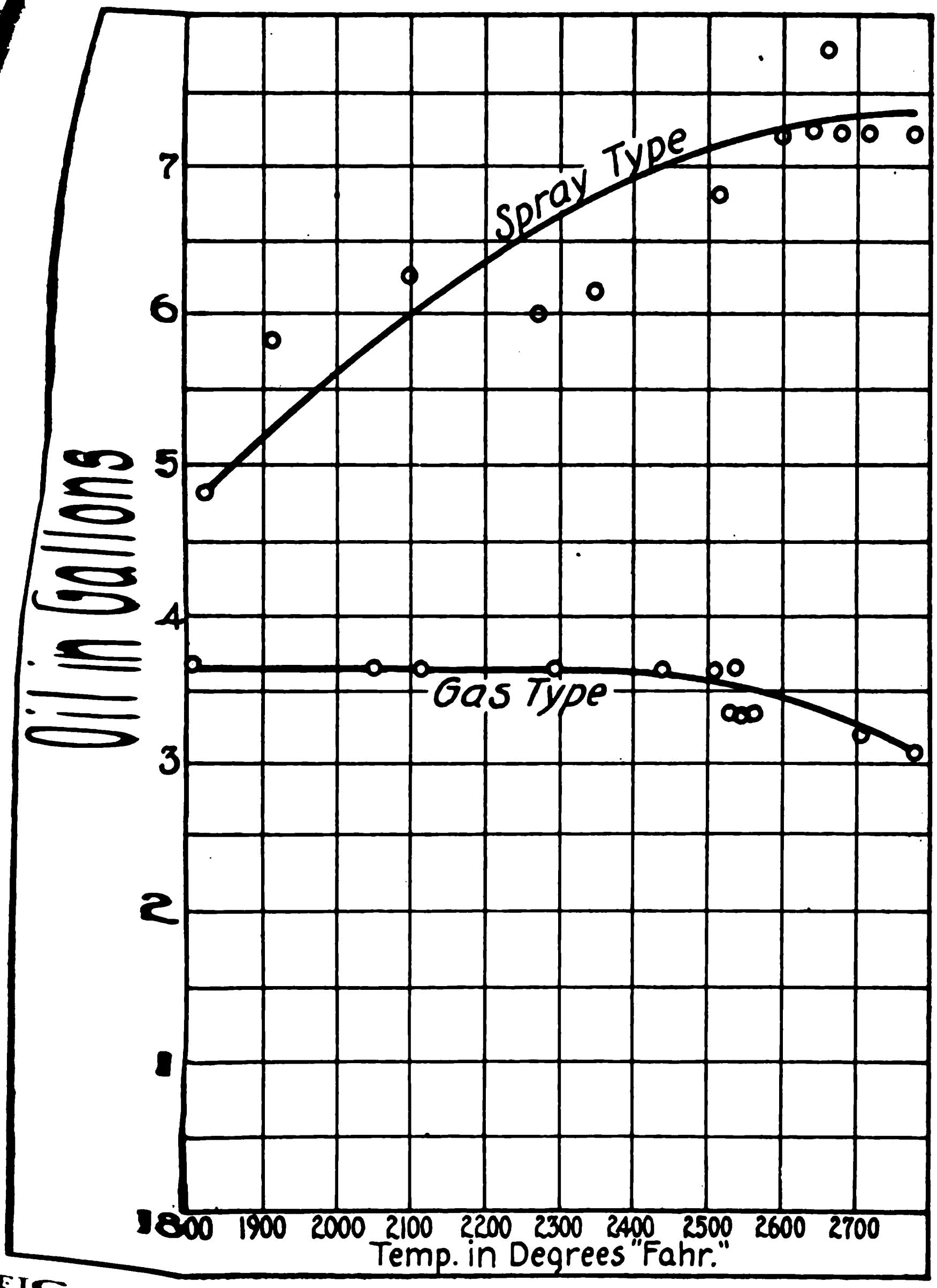


FIG. 7—HIGHER TEMPERATURES ARE NOT NECESSARILY OBTAINED AT EXPENSE OF FUEL WASTE

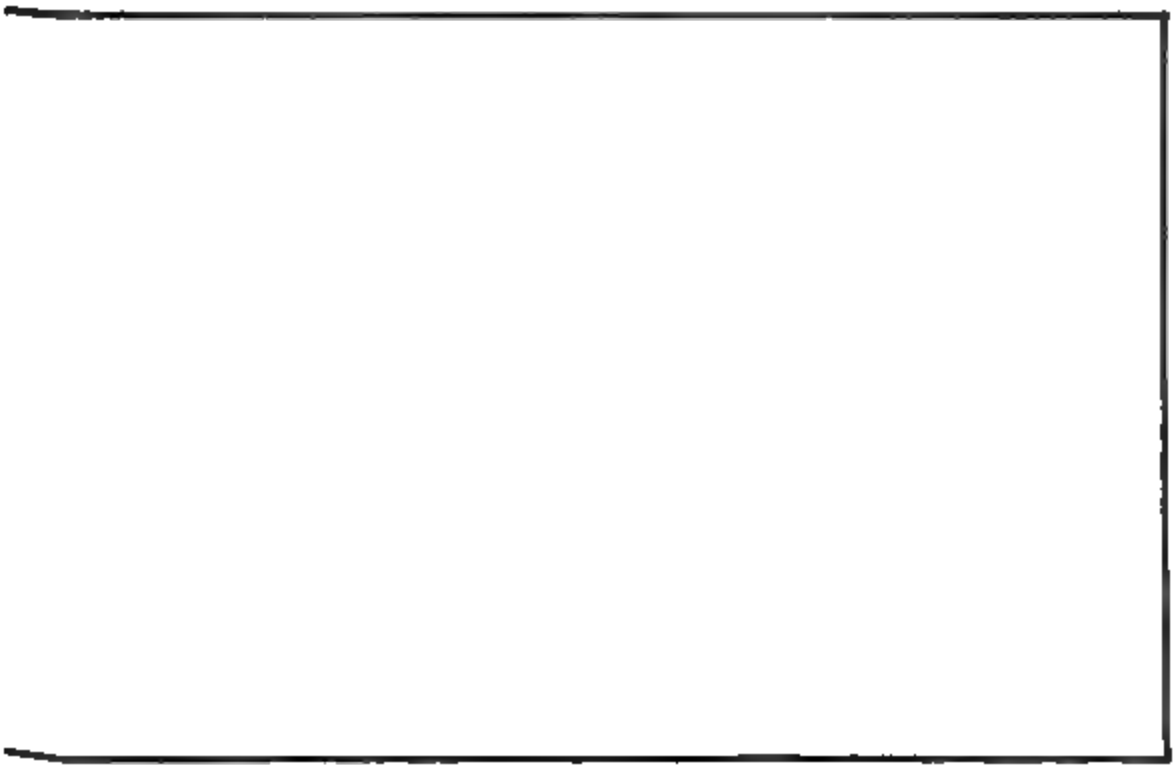
dustry for three distinct purposes, namely power and heating, melting of metal and annealing of metal.

The fuel used for power and building heating malleable industry is no different from that used in o dustries and the problems are identical and have in a been satisfactorily solved. It is up to each malleab manufacturer to adopt what is the best practice for t ditions obtaining in his power house. Some malleable progress has been made, but not in reality of a sut quantity. The subject is being given attention and so periments are carried on but at this time it is prema predict results. In general, some of the developments taken are in the direction of better handling of the fuels some measure the recuperation of the energy from the gases. There is one branch, however, in which progre substantial kind has been made which not alone proc radical saving in fuel but incidentally brings an improve operating methods and conditions which will prove enormous value.

Economy in Annealing

It is to be noted that at the outset in the annealing fuel ratios range from 2½ to 3; that is, for every ton used, 2½ to 3 tons of castings are annealed. The fu ciency for annealing is illustrated in Fig. 3, which sh efficiency of approximately 5½ per cent. By the use c tinuous operating ovens or what is commonly term "tunnel kiln," the ratio of coal used is materially reduce place of an efficiency of 5½ per cent, it appears poss obtain efficiencies reaching up to 30 per cent or a use than one fifth of the fuel. This is graphically illustra the dotted lines in Fig. 3. The advantages aside fro fuel saving, are not directly within the realm of this disc and a few of the essential points are mentioned only in ing. To date there have been developed two distinct ty kilns illustrated in the charts. Both of these heat ind or by mufflers. Fig. 8 shows a cross section of the earlier chamber type. In the center is a line of continuous

FIG 8—CROSS SECTION OF SIMPLEX TUNNEL KILN



—CROSS SECTION OF DUPLEX COMPENSATING TUNNEL KILN

carrying the load on rails and on each side is a muf bustion chamber arranged and constructed of hollow that the interior atmosphere of the tunnel circulates the hollow tile and by that means heats and equalizes perature of the load as required through the successiv A preheating zone as well as a cooling zone together locks at each end are introduced to produce the prope of the operations of heating, soaking and cooling. kilns of this type usually are built in lengths of 30(feet.

Fig. 9 shows a later development which is know compensating type of kiln, arranged for a duplex trucks. The particular differences in this type over the is that the length of the kiln is reduced to about one- the long narrow combustion chambers are removed f interior and arranged to enshroud as a complete m principal chamber or kiln. Also by moving the two trucks in opposite directions, an interchange of heat ends is made possible. Therefore, the preheating of th effected at the same time as the cooling of the outcomi This is accomplished by a center wall having a series ings at each end, both top and bottom, permitting the ci of the atmosphere within the kiln. The heating cha hot zone is arranged symmetrically from each end of Additional economies in fuel therefore can be obtained type of kiln over the simplex type and where building are limited. The advantages of the kiln type oven for annealing are correct regulation of temperatures, treatment of all metal passing through and high econon use of fuel.

Discussion—Fuel and Combustion

MR. TRUDE.—If anything went wrong in the operation of that furnace, how would it be remedied?

MR. SKLOVSKY.—The chance of going wrong exists always but the chances of going wrong in this case are minimized because of the extraneous method of applying the heat. By proper instruments the temperatures can be readily maintained to a desired degree. It is only experience that will tell how long these chambers can be built and how fast they should be fed in. I understand one of those goes in every few hours only.

The trucks are built rigidly and are in an enclosed chamber. There is a layer of brick work and a series of flues above the brick work so that the truck itself is not subjected to heat. There is a sand ceiling placed in each side, and in some cases a fan is applied to circulate the air to take up the heat that is conducted through.

The Chairman, MR. W. R. BEAN.—Those types of equipment are in operation in the pottery industries particularly, but to lesser extent in the steel treating, tin plate, and in malleable industries. Apparently there has not been a great deal of trouble from accident or anything of that kind.

A New Research Department for a Large Malleable Plant

By H. A. Schwartz, Cleveland

For many years the metallurgical research work of The National Malleable Castings Co. was carried on in a somewhat desultory fashion in the laboratories of various consultants to whom work of this character was entrusted. In 1903 a laboratory was built at the Indianapolis plant, primarily for development and experimental work, and this laboratory working in the field of malleable cast iron, together with that at the company's steel foundry at Sharon, working on steel products, were expected to do practically all of the chemical and materials testing work required by the entire corporation.

Central Laboratory Required

The developments of the industry soon required the installation of laboratories, primarily for works control, at all of the company's plants, and the time of the Indianapolis and Sharon laboratories was very largely occupied with work of this character for the mills in question. Such metallurgical research as was required was divided out among these several works' laboratories. In general, problems were attacked in the laboratories of the plant in which they had been encountered, and the work was somewhat co-ordinated by giving over the supervision of all metallurgical activities to a single individual reporting directly to one of the company's vice presidents. This arrangement was at best unsatisfactory, since it was hardly possible to equip all, or even one, of the several plant laboratories with apparatus and personnel adapted to research work of high character. Furthermore, the laboratories were generally overcrowded with routine work so that opportunities for giving time and attention to research problems could be made only with great difficulty.

Realizing these conditions, the corporation began in 1918

also is an organization under the supervision of a chie which is charged with keeping and filing records, main the library, caring for the building and similar fu of a nontechnical nature.

Under the supervision of the materials testing ment, a machine shop is maintained for the preparat special test specimens and the construction and rep laboratory appliances.

The chemical department, in addition to its ten supervision over the metallographic work, is divided in major subclasses. One of these concerns itself with an chemistry, executing the analyses required for carrying work of the other research departments, and, on it responsibility, investigating methods of analysis, pre standardized samples, and otherwise doing original w this field of chemistry.

The other subdivision devotes itself primarily to re in physical chemistry and in other investigations of son similar character.

The equipment of the metallurgical laboratory is able for the use of all the interested departments, and lurgical research investigations are up to the presen ducted in connection with the work of the chemical, pl or materials testing laboratories. The laboratory is l in a fireproof concrete, steel and brick building, approxi 50 x 60 feet, and three stories high, located on Quincy a near Woodhill road. Floor plans accompanying this d tion will sufficiently indicate the space allotment fo different functions of the laboratory.

Arrangement of Departments in Building

The materials testing laboratory and work shop, r ing as they do relatively heavy machinery, are located c ground floor and occupy by far the larger amount of space there available. In addition to these department janitor's quarters and two fireproof vaults, one for the age of inflammables, and the other for the storage of re are situated on this floor.

The second floor of the building is mainly devoted to ffices, and here are found the offices of the department man-ger, of the clerical staff, and also the library and a large oom for meetings, exhibitions and similar uses. The only aboratory on this floor is that of the department of metal-ography, together with the accompanying photographic dark oom. One corner of the floor is devoted to the storage of pparatus and supplies for the various laboratories.

One end of the third floor is given up to four rooms

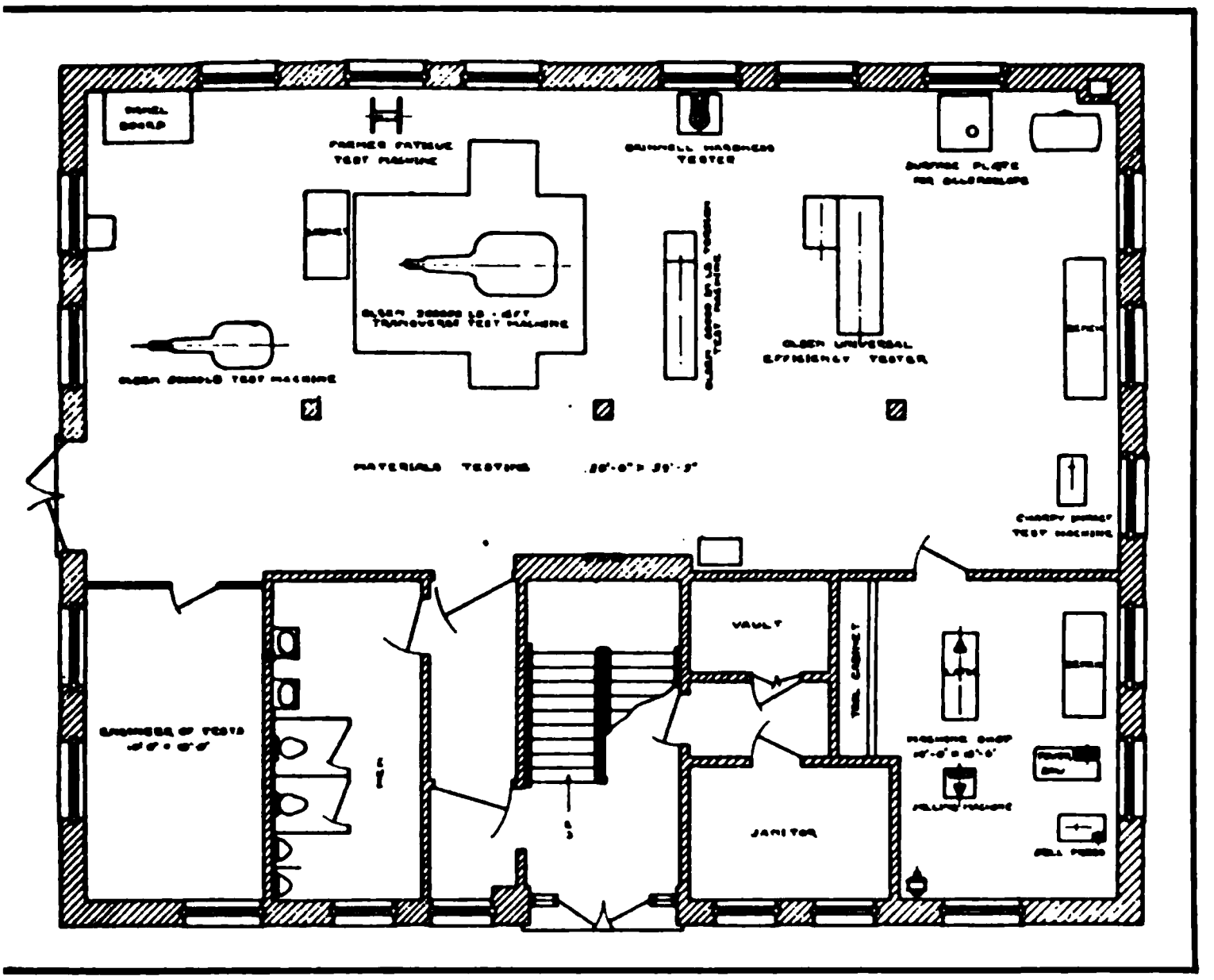


FIG. 2—PLAN OF FIRST FLOOR OF LABORATORY

or the use of the department of chemistry. These rooms re a laboratory for analytical and metallurgical chemistry, ne laboratory for physical chemistry, fuel analysis, gas analysis nd similar operations, the chemist's office, and a balance oom.

The work is not subdivided between the two larger lab-ratories on absolutely hard and fast lines, it being the inten-

tion rather to use one of the rooms for chemical ac for which hoods are necessary to carry off fumes o: and to use the other laboratory for work of such a (ter as to require apparatus likely to be damaged if ind inately used in the ordinary iron laboratory atmosphe:

At the other end of the third floor of the build located the laboratory of the department of physics, an municating with this, the metallurgical laboratory eq for various electrical melting and heat treating ope: Between the metallurgical laboratory and the analytic oratory is a room for the grinding and preparation o ples, the equipment in which serves both these depart Most of the temperature measuring equipment requi connection with the metallurgical laboratory is perm: located in the adjacent physical laboratory, in order t it out of the heat and fumes which might be encou in the former.

Color Scheme Worked Out for Each Room

The chemical, physical and metallographic labor are finished in an acid-proof white enamel on the wal ceilings, with a gray base on the wall; the office in running from cream to tan, and the remaining departm shades running from light gray to lead color. All the ing is indirect, a special high intensity lighting having installed in the rooms in which office work or reading be done.

The dark room is somewhat unusual in that its wa ish is of a dull salmon pink color. Two colors of i illumination are provided—one safe for the handling c tern slide plates or developing papers, the other safe f fastest dry plates which are not panchromatic. In ad safe lights are provided on the developing table givin color of illumination from light yellow, for use with de ing papers, to the very deep greenish tint used for pa matic plate work. It is contemplated that in gener: developing operations will be conducted in tanks in p

darkness. The laboratory is provided with a refrigerator automatically maintaining a temperature of 65 degrees Fahr. for this work.

The laboratory furniture is of antique oak, the table tops being of birch with an acid-proof black finish. In the hood, and on the tables in the physical chemistry laboratory, the table tops are of Alberene stone instead of wood. The tables in the balance room are of heavy concrete construction to reduce vibration to a minimum. A concrete table of similar construction also is provided in the physical laboratory for use where great stability is required. Most of the galvanometers in the physical laboratory are of the wall type and are suspended to the fireproof walls of the building. The laboratory is equipped throughout with hot water heat, hot and cold water, compressed air at 80 pounds and at 4 pounds per square inch, direct current at 220 volts, alternating current at 110 volts, and storage battery current at 6 volts.

The laboratory for physical chemistry is further supplied with oxygen at a pressure of 5 or 10 pounds per square inch by a pipe system running to a Linde tank located on the ground floor. All of the heating devices in the laboratory are electrically operated, gas flames being used only when absolutely required by the work in hand. In general the heating devices are operated on the direct current circuit, although two of the continuous-duty furnaces, one for carbon combustions and one for ignitions, are operated through a transformer on the 110-volt alternating current line. The laboratory is furnished with its own distilled water from an electrically heated still.

The roof of the building, which is reached from other floors by a convenient staircase, is available for experiments involving exposure to weather.

Cement Floors Covered Where Men Stand

A hard maple floor is provided in the offices and library, the other rooms having cement floors with linoleum protection where the workers are required to stand. In the machine shop and materials testing laboratory a mastic floor is pro-

vided to minimize injury to specimens or equipment if acci—— dentally dropped.

An attempt has been made to provide equipment suffi—— ciently complete to permit of investigations of almost any character likely to be required of the laboratory. The mate—— rials testing laboratory is supplied with a 200-pound Olsen 3-screw testing machine of standard construction, and with a 50,000-pound machine of the same type, but of a special

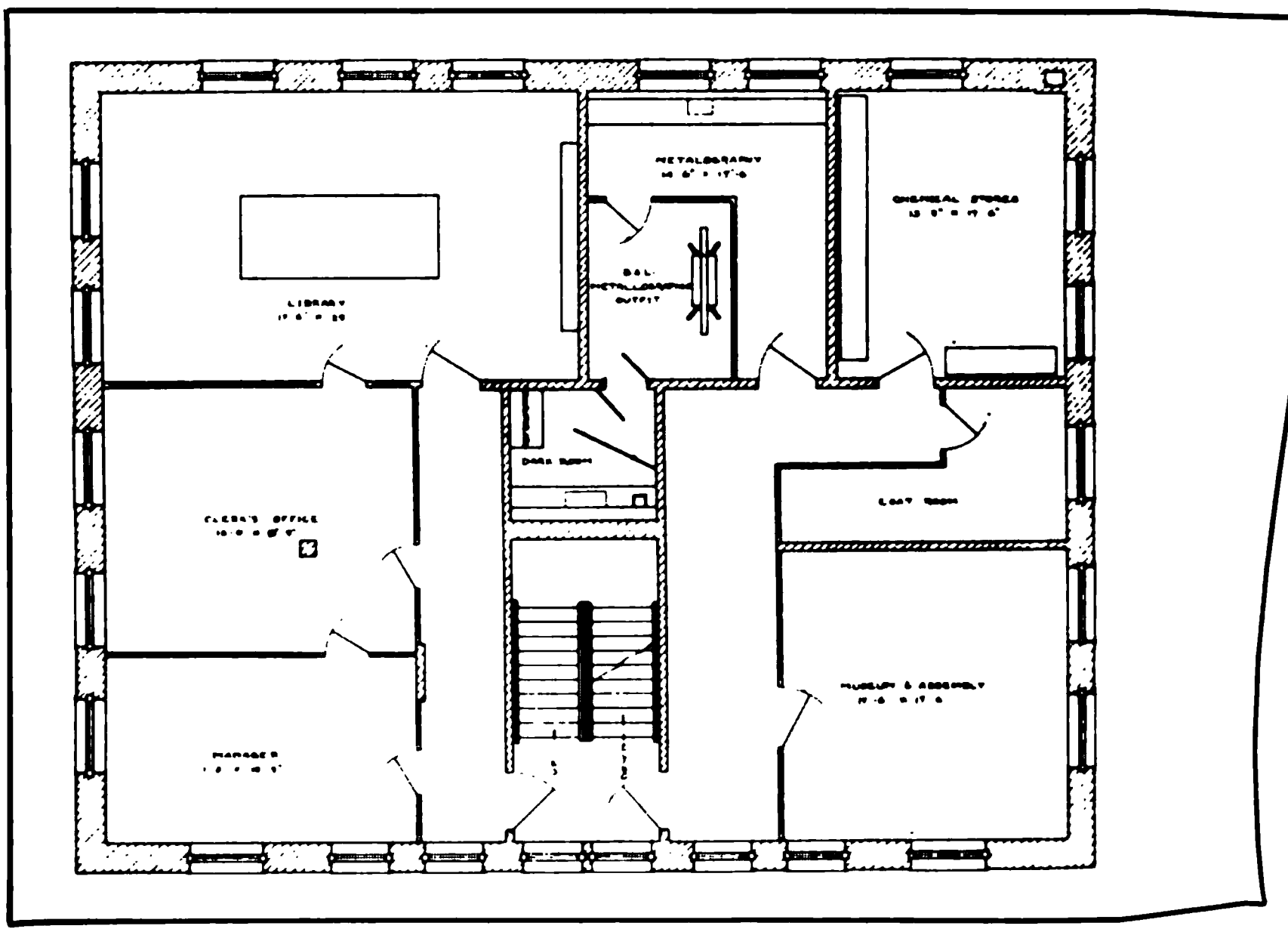


FIG. 3 PLAN OF SECOND FLOOR

sign. This machine is capable of taking tensile test specimens of any length up to 6 feet and compression specimens of any length up to 8 feet. It is further provided with self-aligning holders for threaded specimens, and is located so that special jigs may be used for testing in cross-bending to 6 feet between points of support. The machine is equipped with a substitute poise for light loads, which corresponds to stresses half as large as those indicated on the beam. The vided a 60,000-inch-pound Olsen torsion machine,

and an Olsen universal efficiency testing machine with special integrating and recording watt meters for measuring the power input. These machines, as well as all the power-driven equipment throughout the building except in the machine shop, are driven by individual motors.

The laboratory has also a Charpy impact machine, which is an American-built duplicate of the smaller machine of this type at the Watertown arsenal. A Swedish Brinell machine and a scleroscope are available for hardness tests, and a specially built machine of the Farmer type is provided for investigations in fatigue. The usual accessories consisting of testing machine tools and attachments, a Ewing extensometer, etc., are included in the equipment. Other impact testing equipment for the materials testing laboratory is under consideration, but since this equipment involves various features of design of a very novel character, the machinery has not yet been constructed.

The machine shop, which is operated in connection with this department, has a 12-inch by 5-foot lathe fitted with external and internal grinding attachments, a No. 2 milling machine, bench drill, power hack-saw, and an emery grinder, besides an equipment of small tools adequate to its requirements.

The metallographic laboratory is equipped with an inverted type Bausch & Lomb metallographic microscope provided with both arc and incandescent light. The microscope also is equipped with a special auxiliary optical system for photographing or observing transparent specimens by transmitted light. This equipment is provided with polarizers and analyzers for petrographic work. The range of objectives provided is from 1.9 mm. oil immersion to 16 mm. focus. The camera equipment permits of photography up to 8 x 10 inches in size, and a special microtessar lense is provided for photography at very low magnification. Wratten screens of a complete range of color are provided with this equipment. The polishing devices of the metallographic laboratory are of special design and construction and were built in the company's own shops. They are of the vertical spindle type and

are believed to be superior in design and workmanshi any standard devices of the kind on the market. Sp pains have been taken to maintain the polishing surfac the disks exactly in a constant plane. Means also are vided for holding very small specimens and locating then that the surface on which polishing is done will always re parallel to the plane of rotation of the polishing wheel.

Chemical Laboratory

The chemical laboratory, in addition to the usual eq ment of a well ordered analytical laboratory and a very stock of chemicals, has apparatus of the Braun type for trolytic analysis; both Elliott and United States Steel C gas analysis apparatus; a set of balances, including an A worth with automatic devices for handling the weights capacity of 200 grams, and sensitiveness of 1/50 milligran Troemner capable of carrying 1 kilogram on each pan, sensitive to within 1/10 milligram; and Becker spe gravity and analytical balances. Fraes ovens for drying ei in air or in vacuum, combustion furnaces of the usual Hos type, as well as multiple unit furnaces for organic combust and for oxygen determinations by the Ledebuhr method are cluded in the equipment. There also is available a Kelly elec metric apparatus, equipped with auxiliaries for work in ductivity and hydrogenion concentration. Power driven cr ers and grinders are installed for preparing samples.

Fuel testing work will be carried out in an Emer calorimeter. As already stated, the various hot plates, w baths, etc., used in the chemical laboratory, are electric heated. Motor-driven stirring, shaking and screening dev are provided as required. The departments of chemistry physics share in the use of a Gaertner spectroscope an Valentine refractometer. Vacuum tubes are provided for with the spectroscope, giving spectra of a series of elem for comparison purposes. The spectroscope is equipped a photographic attachment, and a Gaertner comparator is vided for measurements on the spectrum photograph. Si the major work of the physical laboratory may be expec to consist of temperature measurements, it is provided wit

ery complete equipment for work in this field. This equipment consists of standardized platinum-rhodium couples, a eeds & Northrup precision potentiometer, base metal couples, millivoltmeter of the Harrison foot type built by the Brown ompany, standardized electric resistance thermometers, and a ariety of portable pyrometers and auxiliary apparatus, includng a Leeds-Northrup optical pyrometer.

Equipment of Physical Laboratory

For the use of the department of physics there is prorided in the metallurgical laboratory a Leeds-Northrup fur-

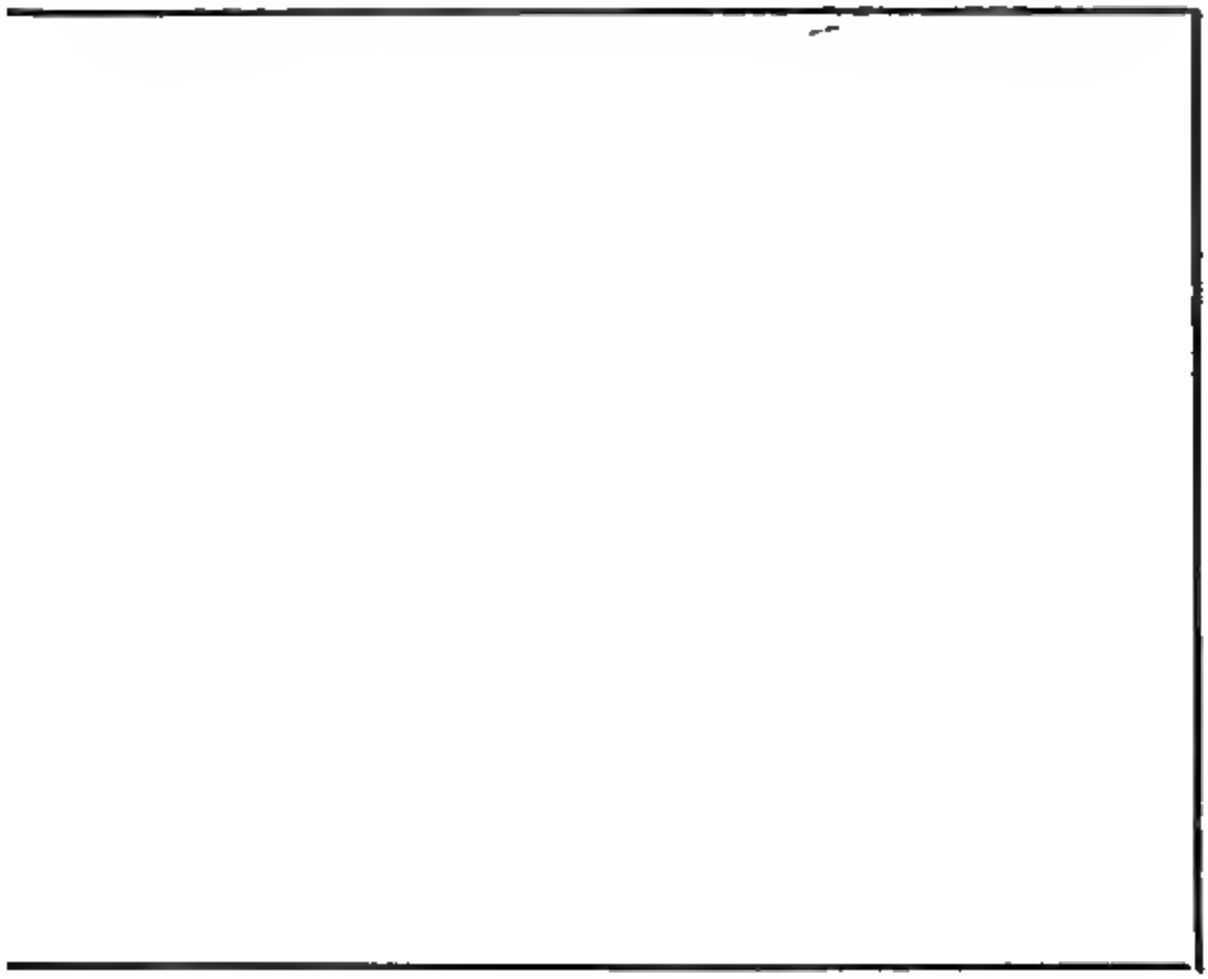


FIG. 4—PLAN OF THIRD FLOOR

nace for standardizing thermocouples. The physical laboratory has further a comparatively complete equipment for electrical measurements, including those of electromotive force, resistance (especially very low resistance), current, induction and capacity. Magnetic measurements can be made on specimens of ring form. A specially designed permeameter of the Ewing double yoke type also has been installed.

Apparatus for work in thermal conductivity of metals has been furnished by Wilkes, and some special equipment constructed for work on thermal expansion is available.

The physical and metallographic laboratories have autographic apparatus of a Leeds-Northrup design at their disposal for the determination of critical points.

The metallurgical laboratory is equipped with an Arsem vacuum furnace and auxiliaries, and with heat treating furnaces of various designs and construction equipped with indicating and recording pyrometers. There also is an electric oven for making investigations in coremaking and similar work where only a moderate temperature is required. Space is provided for an electric melting furnace of small capacity, which, however, has not yet been installed. Direct and alternating current, each of 100-kilowatt input, is provided for in this laboratory.

Books are Carefully Selected

At present the library is rather small, but the 300 or 400 volumes available have been rather carefully selected to cover the field of most immediate interest to the laboratory. A fairly complete list of scientific periodicals also is provided. Further library facilities are to be had in other institutions in the city of Cleveland. Special thought has been given to keeping a systematic set of records and by co-operation with Eli Lilly & Co., Indianapolis, a scheme has been devised which it is hoped will render all of the details of any investigation readily available for future reference.

The detailed plans of the building were made under the personal direction of Ralph W. Ewing, assistant to the vice president of manufacture, from preliminary studies by the writer as to the space requirements of the various departments. The accompanying illustrations are self-explanatory. An ambitious program of research has been tentatively laid out, and it is hoped that at least some of this work will be of a character deserving of publication because of its general interest and importance.

Zirconium in Cast Iron

By Richard Moldenke, Watchung, N. J.

To the list of deoxidizers useful for the purification of cast iron there has been added another ferroalloy, namely that of zirconium. As the list of elements ordinarily in or added to cast iron grows larger a more thorough understanding of the functions of each one of them, particularly those more rarely met with, becomes of increasing importance. We are all familiar with the action of silicon, carbon, phosphorus, manganese and sulphur, but know very little about the special effects of vanadium, titanium, cerium, copper, nickel, chromium, etc. Year by year more of the rarer elements come into daily use, and as they become more reasonable in price through quantity production, the iron industry experiences a corresponding expansion into new fields of usefulness.

Removal of Elements by Oxidation

For cast iron the elements involved seem to be divided into two groups. The first is made up of those not readily removed by oxidation in ordinary good foundry melting practice. The second consists of the elements readily oxidized under conditions involving the presence of oxygen in the molten metal. The two groups shade into each other to some extent, depending upon the degree of skill possessed by the foundryman in handling his cupola or furnace.

The above will be better understood when such elements as sulphur and phosphorus are considered. Both are increased in melting practice by concentration, as they are not oxidized out. Only the action of a basic hearth in open-hearth or electric furnace practice will reduce these elements in quantity, and only through chemical reactions of a more or less complicated nature. On the other hand, it is known that silicon, and manganese undergo definite losses in the melting operation, and mixtures are made up with this situation in view. The

behavior of carbon and iron itself is less certain. Both under conditions of high heat and the absence of a suf of manganese and silicon to protect them. Most foun have seen the brown smoke emanating from a cupola inc a low bed and burned iron, when the silicon of the r was below one per cent and manganese nearly all gor air furnace practice the reduction of carbon is well and in long heats there is enough iron oxide in the l yield defective castings.

Grading Elements According to Ease in Oxidizing

For the group of the less easily oxidized elements iron, where melting is carried on under the best p conditions of air supply to the fuel to prevent undue oxi the following list may serve. It is thought that the given may be that of the most stable first and so on middle ground. This order may be phosphorus, sulphur copper, nickel, tungsten, molybdenum and carbon. Ther carbon as ready to be oxidized or remain unaffected, d ing upon the care taken in melting in cupola or furna order of the elements readily oxidized may be carbon, (ium. zirconium, silicon, manganese, vanadium, alur magnesium, titanium and cerium. The last named is pr the one most easily oxidized.

The order above given is practically guessed at, as is no definite information available on the subject. The has an intuitive feeling that it is so from the practical ob tions made when handling the elements in question in ferroalloys. It would be interesting to subject iron a with all of these elements to a very slow oxidizing atmo while in the molten state, and make continued analys observe the rate of elimination of each as the test progr This should give the order of removal and by inferenc degree of efficacy for purposes of deoxidation in cast

From the many tests made by the author of deoxi of cast iron, it seems that the first effect is the remov oxygen present in combination with the iron. This elim just the amount of the element in question necessary fo

laudable purpose. If the alloy added brings in more than enough for this deoxidation, the balance of the element remains in the cast iron and exerts its particular function upon the properties of the casting. Thus, the addition of say 0.1 per cent titanium may remove all the oxygen present in a ladle of molten iron and yield results that are practically as good as if 0.2 titanium had been used. It is the removal of oxygen—the weakening factor in the molten metal—that permits it to come out with its natural strength due to its composition. It seems as if the crystals adhere more firmly and are given the chance they should have for strength due to a good analysis. If these crystals are of finer quality as the result of added nickel or molybdenum, and if the graphite crystals are small and not too large in number, the product should be a pretty high class metal. Many claims are made for vanadium and other of the rare elements for cast iron and doubtless there is much to the subject. Fundamentally, however, the less oxygen present in the metal before the ferroalloy addition, the more characteristic the effect. Hence the soundness of the policy of devoting every attention to good melting practice so that but little of an expensive alloy need be added to attain a desired effect.

Temperature is Important Factor

One of the difficulties found with the deoxidation of cast iron is the degree of heat involved. It is well known that the hotter the metal the better the effect of manganese added to heats with high steel percentages. Indeed, to get a high steel scrap heat safe for pouring molds, it is necessary to use a good fuel percentage. The higher actual temperature of the molten metal resulting promotes the union of oxygen and manganese, and the result is a casting free from blow-holes. With ordinary cast iron the added manganese, instead of going into the slag, will be found in the metal; possibly partly in combination with sulphur, but having exerted little or no deoxidizing effect. The temperature was not high enough for the reaction.

The consequence of the above is that such metals as aluminum, cerium and magnesium are easily taken up in

molten cast iron, whereas titanium and zirconium tak time and heat for the best results.

Large Percentage of Zirconium Chills Metal

In making tests with ferrozirconium, an alloy cor 30.6 per cent zirconium was used. It was noticed th the smaller percentages the metal behaved nicely in and indicated a purifying action, for the slag came collected for easy removal. The larger percentages gav trouble and cooled the metal considerably so that it wa cult to pour successfully. Unquestionably the alloy better service in steel than in cast iron.

Two sets of transverse tests were made. One gray iron mixture and the other with car wheel scra obtaining results for gray and for white iron.

Gray Iron Mixture

Pig 60 per cent, gray scrap 40 per cent. Average of three ba

Breaking Strength pounds	Deflection inch	Zirconium per cen
2,700	0.10	none
2,920	0.11	0.05
2,900	0.11	0.10
3,050	0.11	0.15

White Iron Mixture

Scrap Car Wheels 60 per cent, white iron scrap 40 pe Average of three bars each.

Breaking Strength pounds	Deflection inch	Zirconium per cen
2,640	0.10	none
2,790	0.10	0.05
2,880	0.11	0.10
2,940	0.11	0.15

As the usual element addition for deoxidation purp 0.10 per cent it will be noticed that the strength incr 6 and 9 per cent respectively. Undoubtedly where larg scrap percentages are used, this increase will be greater oxidation will have been more serious and the temperat

the molten metal higher, making for a better reaction. Further tests in this direction would seem advisable, for the world's supply of zirconium is quite extensive and it should be converted to the ferroalloy as cheaply as titanium.

The above data are given at this time in order that those who are interested may be advised. The tests were made over a year ago.

Discussion

DR. RICHARD MOLDENKE.—The usual way of adding a ferroalloy is to put it in the ladle, or, as I recommend, to put it on a shovel and spread it on the spout of the cupola as the iron comes out. In that way the ferroalloy will permeate all the iron, whereas if you put it in the ladle itself it will float and you will lose about half of that. In that way we can add silicon, manganese and other elements and get good results.

Another way is to add the ferroalloy in the cupola. That is not a very good thing to do, because you are apt to lose a great deal more by oxidation in the cupola than you would in the ladle, but nevertheless it is done, and sometimes it gives very peculiar results. I have known ferrosilicon in the cupola to melt and go through the tap hole, through the ladle, into the actual mold and stay separate from the rest of the casting so when the casting was broken you would see a lump of ferrosilicon in it which you could prove chemically, showing that it is not a good principle to mix ferroalloys in the cupola.

Now furthermore this idea of getting elements into the iron, whether it be silicon, manganese or other things, has another application. It may interest you to know that I am at present working on a very elaborate series of tests on the use of nickel and chrome in cast iron. Pig iron, which contains nickel and chrome, is made and in getting the nickel and chrome in the ore and transferring it to the iron, instead of buying ferronickel and ferrochrome to add to pig iron, you would

get it from the original ore through the blast furnace a pig. Now my thought is that some day we may get th furnace people to add molybdenum ore, zirconium ore, ore, chrome ore, and other ores to their original ores, an get the pig iron to contain these elements which are of va

molding and coremaking designed in the drafting room for the foundry as it is to have the tools and fixtures for the machine shop. This is being done to a great extent in up-to-date plants.

The gates and risers should be properly made and attached to the pattern plates, as each individual casting requires special consideration on account of its shape, size and thickness of metal. A milling machine table that has a very heavy section and is cast solid requires heavy chills and a large feeding riser to take care of the shrinkage and to secure a close grain casting in the deep slots. A table mold should be tipped about 6 degrees when it is poured. The gate should be at the lower end. This keeps the iron from spreading out thin and chilling, besides choking the gate more quickly. Heavy flasks are very important, to hold the sand in place and to keep castings uniform.

We use semisteel in all of our castings, the light and medium castings having from 10 to 15 per cent and the heavy ones from 20 to 30 per cent steel. The cupola is carefully charged by hand. A reservoir ladle is used to insure uniform metal in the castings.

12½ per cent being the most satisfactory in securing the best results. The car wheels give the mixture an additional hardness, which seems to be quite necessary. The steel is of a uniform size, and the car wheels are broken to as nearly uniform size as is practical.

A close check is kept on the ultimate analysis, so that the mixture from day to day is kept nearly constant. This is very necessary on account of hardness on the one hand and open grain structure on the other. If the mixture is too hard the castings will chill, and if any of these castings should reach the milling operations, the high speed cutter would be ruined very readily. The inspection is particularly rigid, and castings showing any signs of being porous or open grained on the outside surfaces are immediately rejected. As will be noticed in Fig. 6, the castings are finished all over.

Description of Cupola

The cupola in which the iron for these tables is produced is lined to 54 inches inside diameter and an average of 10.5 tons of iron per hour is melted. The height of the charging door from the bottom of the cupola is 17 feet, and it has been found that this height works out very well in securing results. This has a tendency to allow the waste gases to heat the charges before reaching the melting zone, thereby increasing the cupola efficiency. The tuyers are nearly continuous and have a ratio of 6 to 1; that is to say, the area of the cross section of the cupola is six times greater than the combined tuyere area. The air is delivered to the cupola from a positive pressure blower at the rate of about 5300 cubic feet of air per minute. This figure is checked from time to time with the use of a blast meter, on which "volume of air delivered" is registered. Another check used occasionally is to determine the speed at which the blower is operating. The revolutions per minute times the amount of air delivered per revolution minus the air lost by friction, etc., gives a good relative idea of the amount of air being blown into the cupola.

The coke bed is measured daily so that an average of approximately 26 inches of coke above the top of the tuyeres is maintained. This measurement is taken as the last of the bed

Tests of Iron for Milling Machine Tables

Analysis of Iron

	Per Cent
Silicon	1.300
Sulphur	0.115
Phosphorus	0.440
Manganese	0.550
Combined Carbon	0.760
Graphitic Carbon	2.540
Total Carbon	3.300

Tensile Test—Turned Specimens

Diameter Inches	Area Square Inches	Strength Pounds per Square Inch	Average Number of Bars
0.799	0.501	36,000	4

Transverse Test—Central Load

Span inches	Specimen shape	Area square inches	Breaking Load pounds	Modulus of Rupture pounds per square inch
10	square	1.00	4000	60,000
12	square	1.00	3600	64,800
12	round	1.20	4000	70,700

Extra Coke Is Added

In order to get the best results with a hard steel mixture it is necessary to add extra coke to the charges, about 350 pounds of coke is being used to melt the charges of 3000 pounds of iron and scrap. This, along with the fact that the cupola, after being charged to the door, is allowed to stand for two hours before the wind is put on, insures good metal at the very beginning of the heat.

The charging floor is exceptionally large and airy, permitting the weighing and the other work in connection with the compounding of the mixtures to be performed with the proper regard for obtaining the best results. Fig. 7 shows a very small portion of the charging floor, but gives an idea of some of the equipment and illustrates a portion of one of the 3000-pound charges. The additional steel is in a wheelbarrow shown at the lower right hand corner of the illustration.

The charging of the cupola is done by hand. The steel scrap is placed on top of the coke and the pig iron then is scattered over the entire area, but not entirely around the lining.

Mixing Ladle Always Is Used

At the beginning of the heat as much iron as is practical is accumulated in the basin to help secure a uniformity of the mixture. Most of this mixing, however, is done with the aid of the mixing ladle, which is located beneath the cupola spout as shown in Fig. 8. The molten iron always passes into the mixing ladle before going into the large ladles, or even bull ladles, when they are used.

If a good pattern is used and good rigging and molding practice is followed, along with the proper melting, mixing and pouring, there is no reason why these tables or any castings of the same requirements should not be made entirely satisfactory to all concerned.

Discussion

A MEMBER.—I would like to ask the speaker if he has experienced any trouble with warping?

MR. LEROY SHERWIN.—We haven't had any trouble of that nature. The table has a fairly thick groove and not an excessive length. It may be necessary to scrape the sand and let the air get down to the casting in order to prevent warping, but on these particular tables we have never experienced any trouble from warping. It also does away with cutting to a great extent. Once in a while we have cutting with gate sand. A horned gate has been found to be most satisfactory in getting a casting that is clean throughout so that when in the machine shop few are returned on account of these defects. We also place a perforated tin over the opening to the pouring hole to hold the iron up and let the slag, if there is any, accumulate there. We take a great deal of pains in skimming our ladle off and as those castings are machined all over we feel that we get very good results.

A MEMBER.—Is there any particular advantage in gating from both ends?

MR. LEROY SHERWIN.—We feel that we get better results from this practice. We have tried pouring these castings with a large ladle at one end and we have tried pouring at both ends, and invariably the castings poured at both ends are better than those poured at one end. We have hot iron in two different places entering into the mold at practically the same time, and we want to maintain our iron at as hot a condition as possible in all parts of the casting, and the main reason for gating is to maintain our heat.

The Chairman, C. H. GALE.--Do you think that filling the mold as quickly as possible gives you better results?

MR. LEROY SHERWIN.—Yes, and we feel that the hotter we can put the iron in there, and still avoid any external strains that might come about, the better the results.

Standardizing Gray Iron Sample Analytical Determination

By Edward J. Fowler, San Francisco

It has been stated in mining circles that the o sample obtainable of a mine or prospect must be tak "blind man" and while such a thought is not meant parage the honest effort of the mining engineer in a true sample, it does have a bearing on the fact t recognized standard as to sampling methods of an rial is quite as essential as standardized laboratory

Considerable attention has been given to the sam pig iron with the usual result that foundrymen have a end drilling of fresh fractures, side drilling of clean p However, at least several reliable sampling methods ducing correct averages are available.

In the field of gray iron products, or at least c ducts in which the ratio of the combined and graphitic play an important part, there is a woeful complexity o ling methods which should compel attention for the pu arriving at some method whereby records from varied will gradually create an interest in the importance of bon ratios for the benefit of the trade and for the e ment of true analytical records.

System Needed in Sampling

At present, without a recognized standard, the foundryman has his sample taken from various parts ings. While the usual metalloids do not vary to any tant extent, the carbon ratio is dependent almost entire the cooling rate of the casting. If a sample is taken half-inch section of a long flat plate the combined differs from a similar half-inch section closer to a hea tion with tendency to delay the cooling effect of th in fact, the combined carbon content materially di half, three-quarter, or 1-inch sections so that the f

man is in the position of not only directing that a sample be taken but also must signify from what part of the casting such sample should be taken and in recording such results he is confronted with the necessity of a complex description of where the sample was taken. He may direct that a sample be taken from a pulley and if the pulley happens to be on the boring mill these chips are used for a sample and may give a reasonable indication of the carbon ratio. On the other hand a sample taken from a rim or spoke may show a ratio which would explain some defects of mixture easily remedied.

It perhaps is unkind to say that practically all of the published carbon ratio determinations are useless; but this is at least a half truth when one considers the distrust surrounding a result which is not backed up by some statement showing where the sample was taken.

Frequently a foundryman who prides himself upon good foundry practice and complete records, publishes carbon ratios showing a cylinder analysis of, say combined carbon 0.60 graphitic carbon 2.60 per cent together with a pulley showing combined content of 0.80 per cent and graphitic carbon 2.40 per cent. This is good as far as it goes, but where was the sample obtained?

Carbon Ratio Factor in Casting

It must be admitted that it has taken a great many years for foundrymen to assimilate the fact that only total carbon is of interest so far as material going into the cupola is concerned but that the carbon ratio is important in the product. Even now some pig iron producers set forth the combined and graphitic analysis of their pig as proving that with low combined carbon in the pig, the foundryman can get low combined carbon in his castings.

This fallacy is fast disappearing with the growing importance of the semisteels, the air furnace and the electric furnace, whose results are so dependent upon the total carbon and the consequent ratio of combined to graphitic. Therefore, now as never before, we should be accumulating carbon records which gradually will build up a theory of the composition of cast iron which will be of great benefit to the trade.

Cast iron at its best is a conglomerate mixture of various metalloids and compounds with various melting points; and all coming down in an apparent liquid stream which in reality consist of a melted fluid carrying along with it pasty compounds of varied formulae. These affect results and cannot be determined by the chemist in the usual commercial analysis. With prevailing various higher working temperatures, we are discovering new and better irons; largely accounted for by the complete melting of such compounds so that their influence can directly improve the mixtures.

These facts are cited for the purpose of calling attention to at least one reason for a standard analysis sample casting. For some years the writer has consistently pursued the plan determining a suitable form of sample or a method which is comparative.

First it seemed possible and desirable to take a part of the physical bar for this purpose but this was discarded for the reason that for some purposes the A. F. A. round bar was used, for others 1-inch x 1-inch x 14-inch bar for 12-inch centers; and also the 1-inch x 2-inch x 26-inch for 24-inch centers; to say nothing of the round and square coupon bars desired by various engineers.

Second, the sample should be poured in green sand at all times to get at comparative results, or in dry sand if such practice was to become standard.

It finally was decided that a green sand sample or plug would be most simple and desirable for average foundry practice and the foliowing plan has been in force for about eight years.

How Test Specimens Are Procured

Eight to 20 plug patterns are made depending upon how many samples are generally desired. These plugs are 1 1-4 inches x 1 1-4 inches by about 4 to 6 inches long, each plug pattern having a pattern lead letter on the bottom, 1, 2, 3, etc., showing on the cast plug. The plugs are molded on end in a drag, no cope being used, and are molded in succession 1, 2, 3, etc., and separated about 6 inches from each other to prevent undue results on account of the influence of heat

from plugs already poured. The foreman directs that plug No. 1 be poured from third tap; No. 2 from sixth tap, etc.; or a plug can be poured from each tap if a special check is required. Bars for physical tests are poured separately. This requires no special direction from the office other than the order "take bars and plugs today." Each plug is poured down the mold without any gate. When the drag is shaken out we have a series of numbered plugs which are brushed with a steel wheel brush to remove all sand. Drillings are taken on the side and put in envelopes numbered to conform with the plug numbers. These envelopes are sent up to the office for record and analysis.

As a general rule when no special tests are required a composite is made for the laboratory sample, consisting of an approximate equal amount of drillings from each envelope; but the envelopes can be saved until results come in and any part of heat can be checked by turning in such envelope if required.

The plan is susceptible to varied changes to suit local conditions or special tests at will without the necessity of any involved instructions. The net result is that all analyses are comparative with the results of earlier years and particularly desirable as records increase.

Records Used Against Complaints

In practice the plan is useful in refuting occasional or even numerous complaints from the machine shop. For example, if it is complained that some castings are coming too hard, we find on checking that where a plug sample has given 0.60 per cent combined carbon the same iron in one casting has always run 0.80 and in another 0.50, so that from having our plug results we can often determine that the machine shop should improve its tool practice. This plan surely has resulted in a minimum number of even occasional complaints. Moreover, the records show that; say a 0.60 combined carbon gives certain results in certain castings; and further if a standard plug is used all printed records can be referred to as A. F. A. standard.

It is quite probable that some better form of sample or some better method can be devised than the plan herein proposed, but in any event the writer believes the A. F. A. should make an investigation and propose a plan whereby accuracy in this respect may be assured, thus removing the general prevailing idea that a foundry is the father of inaccuracies and that a molder knows no closer measurement than a quarter inch on the rule. Now that the electric furnace has come to stay we are finding that "King Carbon" is quite a ruler of our destinies so that true records will be mutually helpful to all who are *founders*.

Report of A. F. A. Committee on General Specifications for Cast Iron

The committee begs to report that in a joint session with the committee on cast iron of the American Society for Testing Materials, held at Asbury Park, N. J., June 23, 1920, a number of matters of mutual interest were discussed, chief of which was the subject of standard specifications for the high-grade cast irons now erroneously designated "semisteel." A large number of representative foundrymen and metallurgists were present and the consensus of opinion was that among well informed circles of makers and consumers of castings, the designation "semisteel" was rapidly losing ground and existed today solely for want of a correct title to fit the cast irons of more than ordinary strength.

Just as the consumer of castings is entitled to protection from misrepresentation by the deliberately created impression that the castings he buys have some of the properties of steel; so also is the foundryman who turns out high strength work entitled to a reward therefor commensurate with the degree of success he has attained. The foundryman who understands the principles of mixture-making and melting to the extent of producing metal which reaches 4000 pounds transverse strength of the standard bar, or 30,000 pounds per square inch tensile strength, is certainly entitled to higher prices for his castings than the man who merely throws in some 5 per cent steel scrap with his charges and figures on getting by with a high invoice by calling his work "semisteel." In other words, your committee feels that inasmuch as a lot of "semisteel" is turned out today which is intrinsically worse than ordinary cast iron to the mixtures for which no steel has been added, the justification for greater quality claims and higher charges should rest upon the foundation of meeting definite specification requirements which are stiffer than those required for ordinary work.

After much deliberation on a satisfactory title for the class of castings involved, the name "high-test" cast iron was adopted tentatively and until such time as collective thought on the subject may have evolved something better.

The subcommittee on general casting of the American Society for Testing Materials was instructed to draw up suitable specifications for "high-test" cast iron, and it was suggested that the transverse strength of the standard 1¼-inch round bar be not under 3500 pounds for light, and not under 4000 pounds for medium and heavy work. The deflection in each case to be not under 0.12-inch. Where tensile tests are desired, the breaking strength per square inch should not be less than 27,000 pounds for light, and not less than 30,000 pounds for medium and heavy castings. It is expected that progress will be made during the year, so that at the next convention some definite action may be reported on the subject.

The subjects of molding sand, and standard nomenclature and definitions of foundry terms were also discussed in joint session, and action taken looking toward early development along these lines.

A. E. OUTERBRIDGE JR.,
S. C. WEEKS,
I. A. WYANT,
RICHARD MOLDENKE, *Chairman.*

Report of A. F. A. Committee Advisory to the United States Bureau of Standards

Your committee begs to report that early in the year a meeting was had with Director S. W. Stratton, of the United States Bureau of Standards, and those of his technical staff interested in foundry procedure. As you all will know, the period of reconstruction following a great war has brought forward a large number of problems, involving huge necessary expenditures on the part of the government, such that practically all research work has had to be suspended for the time being. Lack of an appropriation has, therefore, ended the studies on molding sand carried on by the bureau.

The meeting at Washington could, therefore, do nothing further than have a discussion on those foundry problems which could be handled by the bureau in the event of the raising of funds for the work by private endeavor. The several items at issue are the following:

1. *Molding Sand.* The preparation of ideal molding sands and a study of the treatment of natural sands to render them as nearly ideal as can be. The testing of molding sands for bond, grain size, permeability, strength, etc., with the development of possible standard methods for so testing. The thermal conductivity of molding sands as affected by their chemical and physical characteristics when in service.

2. *Mold Finishing Problems.* The treatment of mold surfaces for the production of clean, smooth-surfaced castings.

3. *Cleaning of Castings.* General subject, and details of the several methods. More specially, the sand blast with specifications for the sharp sand, flint, crushed steel, cast iron shot used; desirable blast pressures, etc.

4. *Sharp Sand.* For purposes other than sand blast.

5. *The Gating of Molds.* Effect on internal shrinkage and casting losses.

6. *Chemical and Physical Laboratory Methods.* Simple methods for determining oxygen in cast iron. Microscopic study of phosphorus, sulphur and oxygen in cast iron.

Electrical Apparatus in a Modern Iron Foundry

By F. D. EGAN, East Pittsburgh, Pa.

Two of the most important questions of the day from a manufacturing standpoint are labor and transportation, both of which make unusual demands on the available supply of common labor. First, due to the shortage of supply, and second due to the transportation conditions, additional labor is required in handling and rehandling at both ends of the haul. As there is no relief in sight, it remains for all manufacturing establishments. particularly the foundries, to consider every available method that may be employed to conserve labor and utilize mechanical or electrical methods to replace human effort.

Electricity, while playing an important part in the manufacture of steel and in the steel foundry, and to some extent in the malleable foundry, is not used in the iron foundry directly in the melting of the product. However, it plays an increasingly important part in the handling and manipulating of the various materials that enter into the manufacture of gray iron castings.

The purpose of this paper is to describe some of the methods employed in a modern iron foundry for the elimination of labor by the use of labor saving devices and the arrangement of the buildings to conserve effort.

Power Supply Does Not Determine Site

The power supply in the majority of cases is purchased from a central station and as electricity is the form of energy that is most efficient and flexible in its transmission, the foundry plant can be located any distance within 100 miles of the power plant. Consequently, it is the last factor that affects the location of a foundry. If the power supply is provided by a central station, the foundry plant need not be located adjacent to a large water supply, as would be the case were the power furnished by the foundry organization.

FIG 1 GENERAL VIEW OF FOUNDRY; PATTERN STORAGE BUILDI IN THE REAR

The following description applies to one of a group foundries for manufacturing iron castings, while the oper ing data applies to two of this group of foundries. T first foundry referred to pours castings weighing from ! pound to 200,000 pounds, while the second foundry pou smaller castings weighing from 1 ounce to 300 pounds.

Fig. 1 shows a general view of the first foundry w the pattern storage building in the rear. The main founc building is 640 feet long by 183 feet 6 inches wide, with lean-to 340 feet long by 40 feet wide on the west si This lean-to is used for housing foreman's office, chemi laboratory, store room and forge shop in one group a the core ovens in the south end of this lean-to in anoth group. The main entrance from the pattern storage buildi to the main foundry is located between the foreman's off and the section of the lean-to housing the core ovens. F

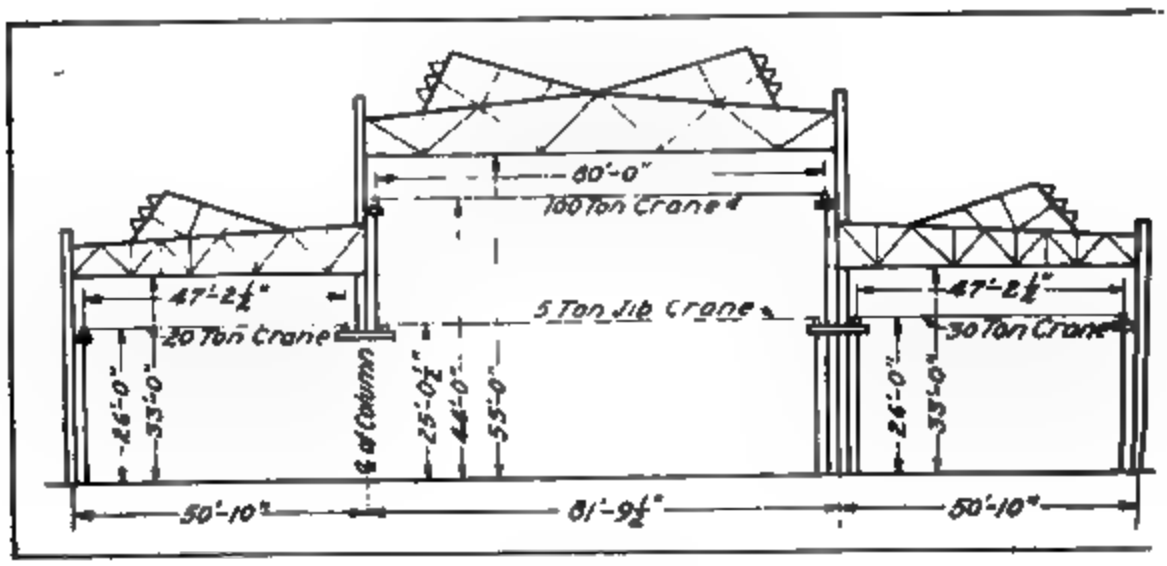


FIG. 2- CROSS SECTION OF MAIN FOUNDRY BUILDING

naces. The location of the melting units divides the east bay into a north and south molding floor. The north floor of the east aisle is served by a 10-ton with a 5-ton auxiliary overhead electric traveling crane, and the south floor by a 20-ton with a 5-ton auxiliary overhead electric traveling crane.

Large Cores Are Required

The nature of the castings is such as to require a number of large cores, and to provide space for this work a greater part of the west aisle is devoted to coremaking. This floor is served by two 20-ton with a 5-ton auxiliary overhead electric traveling cranes and one 30-ton with 5-ton auxiliary overhead electric traveling crane having two trolleys. This last crane is located directly over the core room floor where the large cores are made and also directly over the tracks leading to the core ovens.

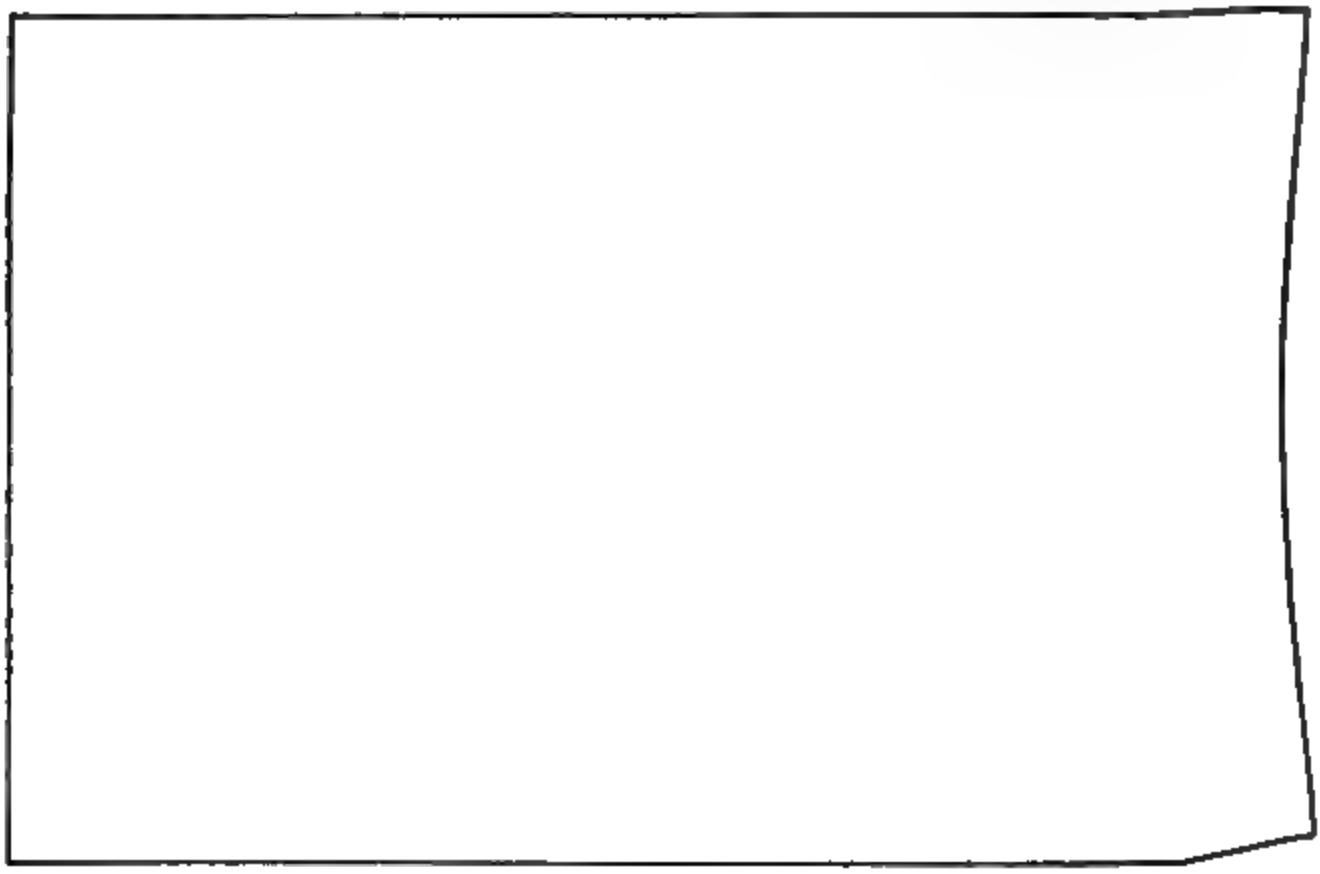


FIG. 4 PLAN VIEW OF MAIN FOUNDRY

At the end of the main foundry building a lean-to 40 feet long by 183 feet 6 inches wide is provided, and is divided into three rooms; two are used for grinding rooms

tribution. The material for the cupolas is loaded on side dump cars operating on 30-inch gage track running parallel with the length of the runway and having two turntables with spurs at right angles, leading to the two elevators for raising the stock to the charging floor. A 5-ton scale is located in each branch of this track system leading to the elevators. A 100-ton platform scale is provided for weighing the charges to the air furnaces. Two 5-ton freight elevators are used for raising the stock from the yard to the charging floor.

The stockyard should be arranged so that the coke can be unloaded into a pit arranged to raise the coke by some form of continuous elevator to a set of overhead bins, so

FIG. 5 ARRANGEMENT OF CHARGING FLOOR

located as to discharge onto the charging floor adjacent to the cupola doors. Provision should be made for screening the coke and making proper distribution of the coke breeze.

Cupola and Air Furnaces

Four cupolas are provided; three are arranged for tapping direct into the center aisle of the main building, and the fourth or smaller unit is arranged for tapping into the molding floor at the north end of the east aisle. Two of the larger cupolas are arranged for charging by two air-operated

charging machines, one located on each side of the cupola. The other two cupolas are arranged for hand charging. The stock, after being weighed, is raised to the charging floor by an electric elevator. Cars can be run to the cupola direct, or stored on side tracks for use at a later time. Empty cars are lowered by another elevator and returned to the yard. The cars are transferred by a car operating on a depressed track. Fig. 6 shows the arrangement of the charging floor, while Fig. 7 shows the arrangement of the cupolas and the air blast pipes. A hand-operated bottom door hoist is provided for raising the bottom doors of the large cupolas. A rotary water mill is used for separating the iron from the cupola cinder.

The air supply to the cupolas is furnished by a group of positive rotary blowers, all of which are driven by adjustable speed direct current motors. Fig. 8 shows the layout of the blower room located directly above the air furnaces.

Two 40-ton and one 15-ton air furnaces are installed and arranged so that any large piece of scrap can be charged by the stockyard crane direct to the air furnaces. Spouts are provided for running the metal to ladle pits located in the center aisle. The air furnaces are connected for forced draft, but at the present time are operated under natural draft.

Molding Floors Divided

The center aisle of the main building is subdivided into two molding floors, one arranged for handling castings weighing 500 pounds to 20 tons and the other floor up to 100 tons. The north end of the east aisle is arranged for handling castings weighing from ½ pound to 500 pounds, while the south end of this aisle is arranged for molding castings weighing from 500 pounds to 20 tons. The greater part of the west aisle is devoted to coremaking. Figs. 9 and 10 give a very good idea of the arrangement of the main aisle showing the location of the overhead traveling cranes and the six traveling jib cranes. Fig. 11 shows the arrangement of the permanent pits for molding the very large castings.

cranes in the main aisle or the side aisles. Two of these hatchways are located in the right and left of Fig. 11. Two of the boxes for handling the sand are shown in Fig. 12 suspended from the hook of one of the cranes in the side aisle as they are being lifted through the hatchway from the locomotive located in the tunnel below.

The foundry building is arranged with gratings at both ends of the main aisle, leading to the tunnel beneath where the old sand is collected after being screened. This part of the sand handling arrangement has not given the satisfaction that was expected. The above arrangement allows the sand to be handled very readily, regardless of the time of delivery, as in winter weather the sand can be run into the pattern storage building and allowed to thaw out to facilitate unloading.

Handling Patterns and Flasks

The patterns are brought into the main foundry building from the pattern storage building by trucks driven by an electric storage battery locomotive, the smaller patterns being moved direct by hand trucks from one building to the other. A large freight elevator is provided in the pattern storage building connecting the various floors.

FIG. 12—METHOD OF HANDLING SAND

central station power company. As the majority of foundries are purchasing power a description will be furnished of the system handling incoming power from the central station. Fig. 17 shows the incoming line and one of the corner towers of the transmission system, the power being furnished at 66,000 volts, 3-phase, 60-cycle and is stepped down in an outdoor substation from 66,000 to 6600 volts, the distribution throughout the plant being at the lower voltage. Fig. 18 clearly shows the high-tension oil switches and the step-down transformers. All this apparatus is de-

FIG. [illegible] 66,000-VOLT TRANSFORMER SUBSTATION

signed for outdoor service, the oil switches being electrically operated and controlled from the company's power house.

Fig. 19 shows the transformers for stepping down the 6600-volt distribution power to the voltage desired at the machines. One group of these transformers is used for changing the voltage from 6600 to 440 for the alternating current motors throughout the foundry building, while the other group of transformers is used for stepping down the

these sets being sufficient to supply the direct current power for the foundry. The small motor generator set shown at the left of Fig. 20 is used for furnishing direct current power for exciting the fields of the synchronous motors driving the two air compressors shown in Fig. 21.

The motor equipment for the first plant consists of 75 direct current motors operating at 230 volts, with a connected rating of 1530 horsepower, and 34 alternating current motors operating at 440 volts, 3-phase, 60-cycles, with a connected rating of 433 horsepower, or a total of 109 motors with a total connected rating of 1963 horsepower. For driving the air compressors there are two 2200-volt, 3-phase, 60-cycle synchronous motors. One motor is rated 159 horsepower and is driving a compressor delivering 1000 cubic feet of air per minute, while the second machine is rated 265 horsepower and is driving a compressor delivering 1500 cubic feet of air per minute. For lighting this foundry there are 262 lamp outlets with a lamp wattage of 79,250. The direct current power is furnished by two 300-kilowatt rotary converters, one machine having a sufficient capacity to supply the direct current power for this plant with a second machine as a spare.

The motor equipment for the second plant consists of 47 direct current motors operating at 550 volts with a connected rating of 740 horsepower and 83 alternating current motors operating at 220 volts, 3-phase, 60 cycles, with a connected rating of 945 horsepower, and four alternating current motors operating at 2200 volts, with the same phase and frequency, having a connected rating of 500 horsepower, driving three air compressors and a fire pump. For lighting this foundry there are 2189 outlets with 1106 lamps installed, having a lamp wattage of 144,480. The direct current power is furnished by two 300-kilowatt rotary converters, one machine having sufficient capacity to supply the direct current power for this plant, with the second machine as a spare.

Data on Operation of Foundries

The operating data as listed below are selected from both foundry plants. Fig. 22 shows four curves, the first

indicating the relation between the iron melted and the electrical power required to operate the foundry. The average value of this curve is 31.7 pounds of iron melted per kilowatt One of the curves in the next group gives the pounds of iron melted per kilowatt to the air compressor serving sandblast machinery. The total iron melted is used, as a separate record is not kept of the amount of iron cleaned by the sandblast method. The next curve of this group gives the pounds of iron melted per kilowatt hour to the air compressors furnishing a general high pressure air system,

FIG. 22—CURVES SHOWING POWER REQUIREMENTS FOR IRON MELTED

while the bottom curve gives the amount of power furnished the rotary converters per pound of iron melted and represents about 33 per cent of the total power consumption of the plant.

Fig. 23 shows a graphical curve of the total power consumption of the second plant. In this illustration there is a curve for two consecutive days, one mounted above the other. The similarity in the power requirements from one day to another is very marked, and attention is called to

this similarity by mounting one curve above the other. In both cases the plant started to work at 5:00 a. m., the load gradually increasing up to 7:00 a. m., where the load curve has almost reached the peak for the morning period. The time of stopping for lunch at 11:30 a. m. is clearly defined, as well as the time of starting at 12:00 noon, the maximum peak for the day occurring between 2:00 and 3:00 p. m. The load starts to reduce about 3:15 and has fallen 50 per cent by 4:00 p. m. and shows all work completed at 5:00 p. m.

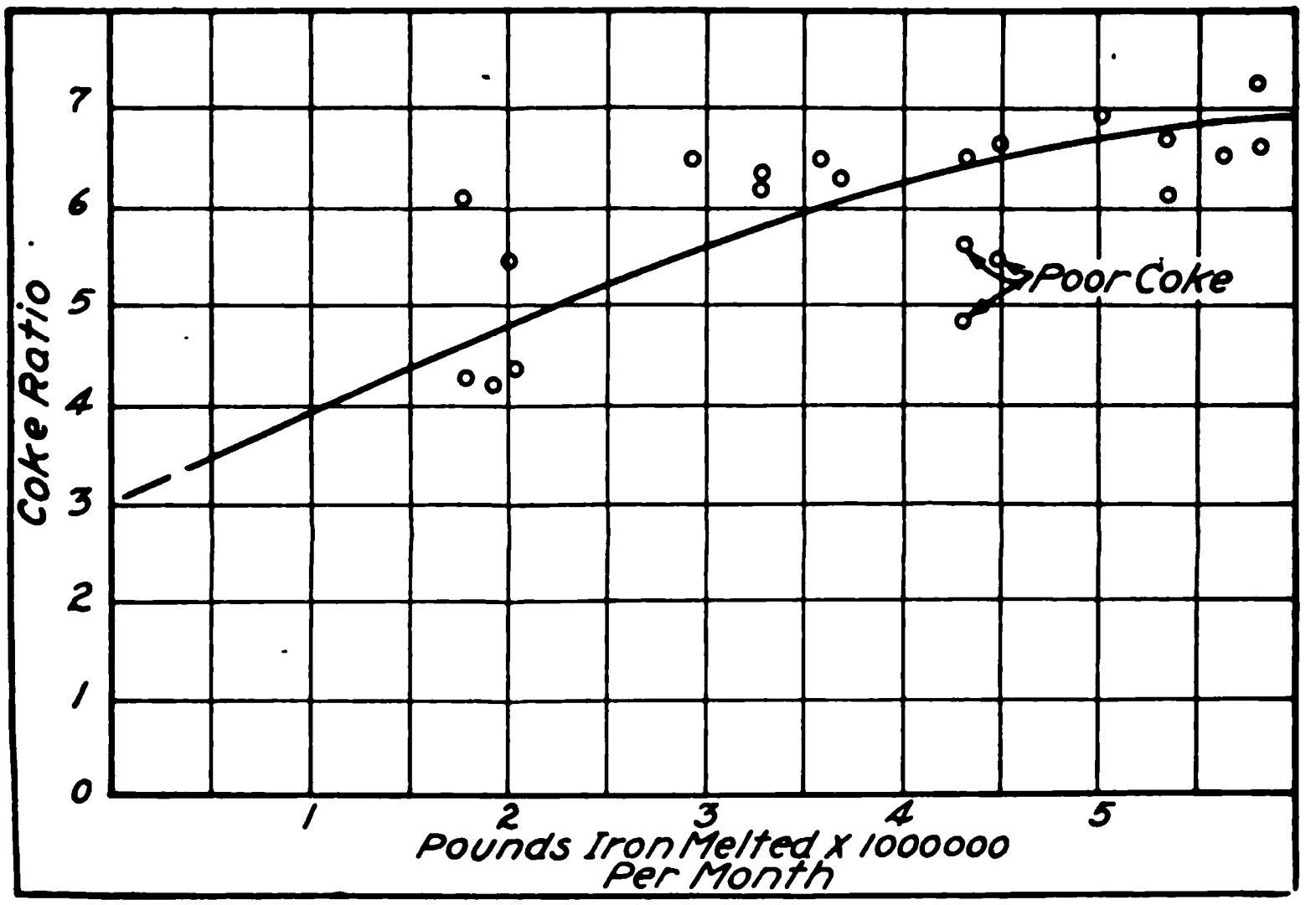


FIG. 24—CURVE SHOWING POUNDS OF IRON MELTED PER POUND OF COKE MONTHLY PRACTICE

The curves in Figs. 22, 23 and 24 can be used as a guide for determining the amount of electrical power or fuel required for furnishing the different forms of energy in an iron foundry of the type melting iron for small castings from 1 ounce to 300 pounds, as most of the operating data was selected from the second foundry.

Determining Size of Transformers

The curves in Fig. 22 can be used for determining he size of the main transformers, the motors and compressors

for furnishing the air supply and also the size of the rotary converters or motor generators for furnishing the direct current power. The curves in Fig. 23 can be used for estimating a probable power bill when used in conjunction with iron melted as listed in Fig. 24.

Fig. 24 indicates the melting ratio or the pounds of iron melted per pound of coke charged. These values include the coke bed in starting and the refuse coke when the run is complete. The curve was plotted from records representing 17 months practice, and covers the same period as shown as the abscissa in the curve in Fig. 22. Several of the points represent the practice at the first foundry plant described in this paper. The maximum production of iron per pound of coke was obtained when the second foundry melted 5,800,000 pounds of iron per month, and the minimum value at the right of the curve is taken from figures showing the operating conditions of a small cupola melting special iron for casting resistance grids and represents extreme practice due to the nature of the product furnished. The points marked "poor coke" represent values obtained this year when the coke furnished was not up to the standard obtained during the past year and a half.

A Note on the Electric Furnace and the Problem of Sulphur in Cast Iron

By George K. Elliott, Cincinnati

Last year the author read two papers* dealing with the then widely unfamiliar subject of treating cast iron in the electric furnace. He described, for the purpose of obtaining more highly superheated and more thoroughly refined iron, a duplex or tandem process that consisted of first melting the iron in the usual way in a cupola furnace and then transferring the molten metal to an electric furnace with basic bottom where it was superheated and refined under a basic carbide slag. Inasmuch as this rigorous refining brought about, among other results, a very marked reduction in sulphur, the subject of low-sulphur cast iron was thereafter projected into considerable of the author's metallurgical life, conversation and correspondence. For it seems that about that same time Dr. Moldenke, ever the alert watchman on the mountain top, was announcing far and wide that iron foundrymen all are face to face with a sulphur problem that, snowball-like as it rolls down along the years, is acquiring a size and direful aspect that is liable to require a serious investigation almost any time, if one does not want to see the whole iron foundry business eventually swamped by the sulphur that is steadfastly mobilizing itself in the world's scrap-iron pile.

The author confesses to his indifference to this sulphur menace at the time of his papers on account of his recent experiences all having been in a foundry employing only low-sulphur pig iron and coke and no scrap iron of outside origin. However, Dr. Moldenke's well timed remarks anent the subject directed considerable attention to the electric-furnace de-

*"Improving the Quality of Gray Iron by the Electric Furnace." Transactions of the American Electrochemical society 5, 175-181. "The Electric Furnace as an Adjunct to the Cupola." Transactions of the American Foundrymen's association 28, 352-361.

sulphurizing process described in the two papers mentioned and before long the author found himself a veritable question-box for inquiries about not only the process but also about the effect of sulphur in cast iron and more particularly about iron very low in sulphur such as was described in the papers. Presumptuous and entirely fruitless would it be for me to attempt an answer to the many questions hanging upon this point, but it is my intention to make this brief paper a general statement of the broader facts connected with low-sulphur cast iron and the process by which it can be obtained.

Objections Against Sulphur

The chief count against sulphur in cast iron seems to be that it is a nonmetal pre-empting a place among real metals, a bold pretender, a counterfeit. This it has been able to do by taking on the semimetallic semblance of the sulphide of a metal; but all the time the foundryman has never lost sight of the fact that sulphur in the form of a sulphide, be it iron sulphide, or manganese sulphide, still is a non-metal and not entitled to an important or vital place in the metal structure.

In plain unfigurative language, sulphides in cast iron break up the metallic continuity of the mass by freezing last, thereby being enabled to collect in veins along the joints between adjacent crystals of iron. This is true even of so small amounts of sulphur as below 0.05 per cent; but we are little bothered or concerned by so slight effects. However, when the sulphur content of cast iron gets to be more than 0.05 per cent it shows a most remarkable tendency to segregate in spots in a way that is liable to increase the harmful effects beyond all numerical proportion. By this it is meant that 0.15 per cent sulphur will harm cast iron through the increased tendency to segregate, more than three times as much as will 0.05 per cent sulphur. The writer's estimate would be that the evil would aggregate at least three times three times. It is this sure tendency to segregate, that in my judgment constitutes the greatest menace of high sulphur. Occasionally there is a foundryman learned, experienced and clever enough to make occasional high sulphur iron castings in which the sulphur is uniformly distributed throughout the metal; in such cases there

always is widespread wonder at the unexpectedly good quality of the metal so rich in sulphur. Here the word "good" is used advisedly and only relatively. Except when certain well defined qualities such as hardness are required and can be attained by no other way, a low-sulphur iron will outshine a high-sulphur one when the full inventory of really worthy qualities is taken. By low sulphur in the preceding sentence I mean *practical* low sulphur of 0.05 to 0.075 per cent, or sulphur scant enough to be incapable of *serious* segregation.

Sulphur Low in Electric Furnace Heats

However, the basic electric furnace process that was described in the papers mentioned, often produces sulphur so far below 0.05 per cent that the question is raised as to the advantages accruing from sulphur as low as 0.020 per cent, for example. In this connection I can recall one heat that emerged from the tandem process with the sulphur so far eliminated that it took a gravimetric analysis in the laboratory to discover the 0.009 per cent that constituted the remnant. To return to the question as to the advantage of so low sulphur, academically it can be answered that the amount of non-metallic intercrystalline film breaking up to some extent the solidarity of the metal mass, is definitely reduced to a minimum that formerly was capable of expression only on paper and not in fact. Practically answering the question, it must be admitted freely that in the present state of testing and measuring the qualities of cast iron, we are unable to fix positively any pronounced advantage in gray iron castings with 0.015 or 0.030 per cent sulphur, over those with twice those amounts of sulphur. However, there is a sort of speculative satisfaction and assurance in knowing that limits can be and are being achieved in every day practice that certainly are safe beyond all shadow of doubt; that the danger line at least is put a long way off. Possibly a more material advantage in this extremely low sulphur is the fact that the degree of desulphurization can be taken as a very reliable gage of the amount of general refining that has taken place in the metal bath, having in mind particularly deoxidation and degasification.

Another rather indirect but very significant benefit derived

from low sulphur in cast iron is a certain independence high or moderately high manganese. One of the reason: the presence of this last element in cast iron is the neutr: tion of the evil effects of sulphur, through preventing the fo tion of pernicious iron sulphide by forming manganese sul in its stead. Frequently iron is overdosed with mang: merely to take care of anticipated high sulphur and not se is the surplus manganese sufficient to increase the har and correspondingly decrease the machinability of the cas: If the metal is known to be very low in sulphur, the mang: may be used more sparingly, with a saving not only of m: nese but of machine shop finishing costs. The fact has ir been noticed that electric furnace refined iron with sulphur, will be harder than cupola iron of the same si combined carbon and manganese content and higher sul: This probably is because the manganese, relieved almost en: of the charge of policing that bad character sulphur, is rel to other activities and so goes to work forming double car with iron and carbon which has the effect of increasing i rially the hardness of the metal. Theoretically one par weight of sulphur unites with 1.7 parts of manganese to 2.7 parts of manganese sulphide; that is, sulphur at 0.12 cent will unite with 0.20 per cent manganese to form 0.32 cent manganese sulphide. Assuming then that we hav iron with 0.80 per cent manganese and 0.12 per cent sul at most only 0.60 per cent manganese is available to carbide and harden the iron. If, however, the sulphu reduced to 0.02 per cent, there is needed only 0.034 per manganese to take care of it, leaving 0.766 per cent mang: to form carbide. This represents an actual increase in m: nese carbide of over one-fourth. Surely, so great an inc is not without some effect upon the hardness. To retai more than the manganese-carbide-bestowed hardness of original iron having 0.80 per cent manganese and 0.12 cent sulphur, the manganese would need to be only about per cent in the case where the sulphur is reduced to 0.02 cent. In this connection the author is called upon to say differences in hardness such as are illustrated in the prece example probably would not be measurable or even noti

in large castings, but that it is distinctly manifest in small ones he can aver from repeated experiences. Also this question of hardness is intermingled with the closely related subjects of the increased attraction of high-manganese irons for carbon, and of the protective influence of high manganese against oxidation in the cupola, both of which have a very considerable bearing upon the subject of hardness.

Sees Wide Use for Scrap

Instead of striving for and accomplishing the low sulphur limits that have just been mentioned it is entirely probable that the more popular practice will be to resort to the use of more scrap or of pig irons running higher in sulphur, for example making mixtures coming from the cupola with 0.120 to 0.150 per cent sulphur or even more, and by duplexing in a basic electric furnace reducing that element to about one-half. In the finer grades of iron foundry work so great a reduction of sulphur as this would show benefits that would be practically demonstrable. It is undeniably possible to improve the general qualities of really high-sulphur cast iron by desulphurization. The more abundant widespread use of scrap is rapidly becoming not only an economic duty for the sake of the conservation of our raw materials, but also in this time of high freight rates, a well defined need. Here we have a distinctly useful application of the basic electric furnace for rendering fit for service scrap that normaily is more or less unfit on account of its accumulation of sulphur.

Desulphurizing Iron and Steel

The chief process used for desulphurizing iron and steel in the electric furnace may be set down in the chemical reaction

$$Fe\ S + Ca\ O + C = Fe + Ca\ S + CO$$

or

$$MnS + CaO + C = Mn + CaS + CO$$

It is quite probable that the full reaction or sequence of reactions is more complex than here shown although the given reaction does truly represent the essential outline of what takes place. The reaction means that the sulphur is removed from the metal bath as calcium sulphide which is soluble in the slag

and not in the iron. A reducing condition is necessary for the success of the reaction, for were the furnace atmosphere oxidizing in nature, the calcium sulphide would quickly be converted into sulphate and as such in turn would react with the iron to form once more iron sulphide which was the original compound of the sulphur in the iron and so would re-enter the bath. From the reaction we see that carbon is required in addition to the lime in the slag; indeed the presence of some calcium carbide (CaC_2) in the slag is a required security that the bath is in the essential deoxidized condition without which the elimination of sulphur is impossible. This is made by throwing powdered coke over the not too thick or viscous slag covering the bath.

In closing the author wishes to emphasize the reducing or deoxidizing nature of the reaction by which desulphurization is accomplished in this electric furnace process. By it getting rid of sulphur is made a double blessing; and who knows what and how many of the virtues of basic electric furnace iron are in reality due not only to low sulphur but also, and perhaps to a much greater degree, to the chemically *deoxidizing* influences by which it has been refined?

Discussion on Sulphur in Cast Iron

A MEMBER.—We have a lot of scrap in our foundry running pretty high in sulphur, and I would like to know how we can use this scrap without making more scrap. In other words, how shall we get rid of the sulphur.

DR. RICHARD MOLDENKE.—Last year if you remember I told you that the war had been worse on the foundry, perhaps, than upon any other industry in the country, because enormous quantities of scrap were used with very small amounts of pig iron. Consequently the sulphur content in the scrap has gone up to very high points. I have made castings with 0.32 sulphur which were useful. Now such castings all eventually find their way into the scrap pile, and consequently we will be confronted within the next 20 years with lots of trouble, due to sulphur. Now of course the evil of sulphur has been tremendously exaggerated, in a way. You can make very good castings with high sulphur, provided only that you melt right. As I said, I made castings with 0.32 sulphur which had no blow holes at all, but they were weak. Now, on the other hand, if you make high sulphur castings with a low bed, then you have all kinds of trouble, because you have an oxidized iron, full of sulphur, which is rotten. There are two ways in which that can be overcome. One is to use very small percentages of scrap and very large percentages of pig, which is very expensive. That dilutes the sulphur. The other way is to get the sulphur out after you have got it in, and that is accomplished by the electric furnace. Mr. Elliott, so far as I know, is the first man who ever tried and he did it by melting in the cupola and refining in the electric furnace to get out the sulphur. But in the electric furnace you not only have desulphurization but also deoxidation and superheating. Consequently, you have in the duplex process of cupola melting and electric furnace refining the solution of these troubles.

MR. G. K. ELLIOTT.— Doctor Moldenke asks how low you can get the sulphur and how much it costs. Those two questions are necessarily closely linked together. In the paper here I mention the lowest figure which we have been able to reach, which was .009. That was in the nature of a demonstration to see what could be done, and I do not think it economical to attempt such a reduction in sulphur. In the first place, I see no gain, and in the second place, it prolongs the heat tremendously. The cost of it, of course, runs parallel to the time.

Now if you have a mixture which is running extremely high in sulphur, 0.13, and if you need to cut it down to 0.05, as Doctor Moldenke suggests, it may take you 45 or 50 minutes to an hour, depending somewhat upon how skillfully you have mixed your slag. If your slag is not rich enough in lime, your slag will soon become saturated and you will not be able to take much sulphur from the bath, and you will be running along and only dropping a few points at a time, but if you keep your bath mixed with the proper proportions of lime, keeping it well carburized, I should say you could reach those figures in from 40 to 50 minutes, depending somewhat on your temperature of gas.

DR. RICHARD MOLDENKE.—How about the cost?

MR. G. K. ELLIOTT.—The cost depends on what you pay for your current. It will consume from 200 to 350 kilowatt-hours, depending on just how much sulphur you are starting out with and how much sulphur you want to wind up with, and how much superheat you want to have. I cannot give you a definite figure on that because it depends on so many variables.

DR. RICHARD MOLDENKE.—If you melt in a cupola under normal conditions, and your current is not too expensive, will it mean a quarter of a cent a pound added to the cost?

MR. G. K. ELLIOTT.—I would say a quarter to a half cent a pound.

DR. RICHARD MOLDENKE.—The people who make castings, to whom the cost might amount to 15 cents a pound, can easily avoid that; those who make castings at three cents a

pound cannot afford it. If you cut down to about .05 from the high sulphur, at a cost of a quarter to a half cent a pound, a lot of foundrymen can afford to do that.

A MEMBER.—Isn't it true that sulphur increases strength up to a certain point, and after that it decreases it?

MR. G. K. ELLIOTT.—It seems so. There are so many things that affect the strength of test bars it is pretty hard to say positively.

A MEMBER.—Our experience has been on a very small furnace, with a comparatively small amount of metal. We melted scrap containing over 0.2 per cent sulphur and by the time we got the slag in condition, that is, got a good true carbide slag, which was about 15 minutes, we took the first sample and found we had the sulphur down to less than .01. In that case we had a depth of metal of perhaps not over three inches. We had a good ratio of slags compared to the volume of metal we were refining. I should think that fact would be quite important.

MR. G. K. ELLIOTT.—It evidently would be. You want to expose as much of your bath as you can to the slag in order to save time.

A MEMBER.—The removal of the sulphur or the reaction takes place right on the surface, where the slag and the iron come into actual contact. It seems to me the more shallow the bath, the quicker that removal would take place.

MR. G. K. ELLIOTT.—At the same time you don't want it so shallow that the furnace would be too unwieldy in size. You must strike a happy medium.

A MEMBER.—Isn't it an advantage in the duplex process to be able to lower the total carbon and gain strength in that way?

MR. G. K. ELLIOTT.—Yes, you can do anything with the carbon within the limits of chemical possibility. You can lower the carbon by diluting it with steel or you can run up the carbon by throwing in electrodes or pieces of wood. I have run it up by taking 2 x 4's and jamming them into the flame.

A MEMBER.—Is there much advantage to be hoped for carrying phosphorous lower than it is ordinarily carried cast iron?

MR. G. K. ELLIOTT.—I have worked quite a bit with l phosphorus irons and I rather like them, because they seem be pretty strong. They also seem to have good dynamic prop ties when they are put to a dynamic test.

DR. RICHARD MOLDENKE.—In making a number of te on nickel chrome iron, I found that I had to begin my class cation on the phosphorus. I considered everything below low phosphorus, between that and 0.7 a medium, and eve thing above 0.7 high phosphorus.

MR. G. K. ELLIOTT.—It is entirely possible to melt c charges in the electric furnace; it is frequently done, but in a great tonnage I wouldn't advise it, because you could melt cheaply in the cupola. I do not think the cupola will ever thrown out of the foundries. Then let the electric furnace ta it up where the cupola lets off, through your superheating a refining. We practically make all our malleable requireme in the electric furnace, melting down cold charges simply beca the tonnage is not enough to pay us to run a cupola stead You can get good results, but I think it is too expensive regular practice.

A MEMBER.—What are some of the causes of the red tion of carbon?

MR. G. K. ELLIOTT.—The chief one is the use of ru scrap or rusty pig iron or any form of rust. Rust is the ox of iron and is going to unite with the carbon and cut it dov In fact, if the carbon is too high, an easy way to cut it in t electric furnace is to shovel in a little oxide of iron, usi ore or mill scale. That is the chief reason. You might s that is almost the only cause for reduction of carbon unless, course, you are deliberately diluting the carbon by adding ste

Casting Losses In Aluminum Foundry Practice*

By Robert J. Anderson, Pittsburgh

This paper is a brief abstract in part of United States bureau of mines bulletin No. 200, which will be published later, and the object in presenting the paper now is to make immediately available the main results of the recent investigation made by the bureau of mines of the casting losses in aluminum-alloy foundry practice.

Appreciable and, in many instances, readily avoidable losses have occurred in the production of aluminum-alloy sand castings for many years. In many of the small foundries in the United States, and in the larger and more efficient plants as well, the percentage of castings rejected because of foundry defects has reached excessive figures at times. The late war, which intensified the errors of peace, brought this fact out strikingly in connection with the production of light aluminum-alloy sand castings for aircraft engines, and the rejections of these castings were as high as 30 per cent on the average during a large part of the time. These were, of course, special castings, and, generally speaking, the foundries had not had any experience with work governed by the rigid specifications of the bureau of aircraft production.

However, both before the war and at the present time, aluminum founders have had difficulties with particular and constantly recurring defects in sand castings. The small shops, in many cases, have never been able to successfully correct these, even to their own satisfaction. In co-operation with *The Foundry,* and by direct contact with the majority of the larger aluminum foundries of the country, reports of difficulties experienced in the production of aluminum-alloy sand castings are continually being sent to the bureau of mines, and in this

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way it is felt that much light may possibly be eventual thrown upon the question.

Object and Method of the Investigation

The present investigation had for its object to ascertai first, the amount of the casting losses in aluminum foundi practice in the United States; second, to determine the pr dominant causes for these losses; and third, to suggest metho if possible, by which these might be reduced. The proble was studied in the following way: (1) By circulating a que tionnaire to all aluminum foundries in the United States, a analyzing the data given in the replies; (2) by gathering exis ing production records at a number of representative foundrie (3) by inspecting the daily production of different kinds castings at several representative foundries; and (4) by invest gating general conditions in the industry. The resulting da have been collated, analyzed and summarized.

Unfortunately, data were not supplied by some lar foundries, but it is scarcely possible that the practice of tho which did not reply to the questionnaire is any better than t best practice of those which did. However, the informatic kindly supplied by the majority of the foundries was mo gratifying, and in the main, considerable interest was shown the investigation. Necessarily, the data supplied varied consi erably in exactness and reliability, but from the mass of info mation gathered, it has been possible to arrive at what believed to be a close approximation of the average casting lo of the country incurred in aluminum founding. Moreover, t information gathered has proved to be useful in outlining futu investigations in the metallurgy of aluminum.

The author is indebted to the many foundry superinten ents, metallurgists, and others connected with the aluminur foundry industry, who have kindly supplied data and offer suggestions during the course of the investigation. Owing the confidential nature of the source of much of these dat it is unfortunately necessary to omit mentioning names.

A complete study of the causes for and methods for t prevention of defects in aluminum-alloy sand castings, even a single foundry, is one which is beclouded with many dif

culties, but, at the same time, it is one that can be greatly simplified by keeping detailed records and classifying the defectives and wasters. The castings produced during a day in a foundry may be divided into good castings; castings with remediable defects, which can be salvaged by welding or soldering; and totally defective castings which are returned and remelted. Of course, it is difficult to draw sharp lines of demarcation among these three classes, and this fact makes evident the need for experience and good judgment in inspection. Whether any casting is accepted or rejected depends upon the kind and amount of the defects, upon the use to which the casting is to be put, upon the amount and character of the subsequent machining in relation to the defects, as well as upon the specifications. A defect which may cause one type of casting to be thrown out may be of no importance in another type of casting.

Aluminum-alloy castings may be rejected for one or a combination of causes including cracks; sand holes; chill blows and core blows; cold shuts; hard spots; porosity, leaks, and general unsoundness; uneven walls and core shifts; hard ramming and soft ramming; breakage on trucking, handling, chipping, cleaning, and welding; cope drop; short pour; dirty or broken cores, and sand or paste in the cores; run out; molds crushed in core setting; gates washed in; poor patching; wet sand, and improperly tempered sand; draws and shrinkage; warping; broken molds; and inferior aluminum pig and aluminum-alloy pig. The regulation of shrinkage and the prevention of cracks are two of the most serious difficulties encountered in the production of aluminum-alloy sand castings, and rejections because of these defects are heavy on the average. The occurrence of cracks at a given plant is likely to be sporadic—cracks being quite prevalent for several days and then disappearing altogether for a time. Blowholes, porosity, and unsoundness in aluminum-alloy sand castings are also common defects, but they are more readily traceable to some definite causes than are cracks.*

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*Anderson, R. J., Blowholes, Porosity, and Unsoundness in Aluminum-alloy Castings, Bureau of Mines Technical Paper No. 241; *The Foundry*, vol. 47, 1919, pp. 579-584.

The numerous typical defects given above are of common occurrence in aluminum-alloy sand castings, and these defects may be so serious as to cause rejection of the castings. It is without the scope of the present paper to discuss these defects in detail or the causes for them. This phase of the subject is treated at length in the bulletin to be later published, and it will also be discussed in a series of articles to be published in *The Foundry*.

Factors Affecting Casting Losses

The production of any casting starts in the drafting room, and unfortunately many defective castings are made on the drawing board. Design is a factor over which the foundryman has little, if any, control ordinarily, but many losses can be prevented at the outset, if the foundry foreman, molder, and coremaker are called in for consultation when the question of design arises. Perkins* has outlined five essentials to insure low casting losses in founding, and these will bear repetition:

1. A design from which good castings can be made continuously.
2. The combined ideas (coremaker, molder, cleaning-room foreman) of all interested in the making of the casting, so as to obtain the best equipment for its production.
3. A substantial incentive offered for good work.
4. Having made a good casting, to insure its shipment in as good condition as when it left the foundry.
5. A clean well-equipped shop.

In making a detailed analysis of the casting losses in any foundry, it is necessary to carefully consider the factors affecting these losses.

The factors which affect the percentage of castings rejected for whatever reason may be divided, for convenience, into four main classes: Metallurgical factors; molding factors; miscellaneous factors; and the human element. Under these main classes, various factors fall automatically. A classification of the variable factors which alone or combined affect casting losses is given below, but it is beyond the scope of the present paper to discuss them in detail. There is this to be said with regard to molding for aluminum-alloy castings, and this

*Perkins, J. M., Defective castings how to handle them, *The Foundry*, vol. 38, 1911, pp. 276-277, and Trans. Am. Foundrymen's Assoc., vol. 20, 1912, pp. 355-361

is also true for all nonferrous work as well as iron and steel, namely, casting losses are markedly affected by the individual skill of the molder. It is presupposed, of course, that technical control (chemical, metallurgical and physical), is maintained at a satisfactory level, but the problem of obtaining good sound castings is largely dependent upon skillful molding technique, adequate supervision, and the correct equipment. Given proper casting design, the following factors may be regarded as intimately connected with losses in production:

A. Metallurgical Factors.
   1. Kind and quality of the melting change.
      Chemical composition of the alloy; quality of the aluminum pig or the aluminum-alloy pig used; amount and kind of scrap charged, and method of introducing the additive elements, for example, copper.
   2. Melting Practice.
      Kind of furnace and furnace atmosphere; time and temperature of melting; composition of the containing vessel; kind and quality of the fuel used; and use of fluxes.
   3. Pyrometry.
      Melting temperatures and pouring temperatures.
   4. Metallurgical specifications.

B. Molding Factors.
   1. Molds and methods of molding.
      Kind and character of the molding sand; power machine, hand machine, floor and bench molding; patterns; flasks and boxes; kinds of molds made for different castings; methods of gating; position and number of risers; venting; and handling and placing molds.
   2. Cores and core setting.
      Green sand and dry sand cores; coremaking; handling cores in the foundry; and core setting and coring-up.
   3. Inspection of molds before closing.

C. Miscellaneous Factors.
   1. Pouring practice.
   2. Shaking out.
   3. Handling and trucking castings.
   4. Grinding, chipping and cleaning.
   5. Welding and repairing.
   6. Inspection of castings.

D. Human Element and Labor.
   1. Quality of the labor.
   2. Labor turnover.
   3. Piecework and day-rate wages.

The available space does not permit of even a brief discussion of the above factors, but one point in molding is of

particular importance. Mr. Traphagen* presented a most interesting paper before this association last year on scrap losses in iron and steel founding, which especially emphasized this point. He suggested that each foundry should employ a competent experimental molder who is engaged to study and devise the most suitable method of gating and heading each casting job that comes into the shop. When the desired method of molding has been worked out, and sound satisfactory castings result, the job can be put into production. Too often, particularly in jobbing, the patterns are handed to a molder with instructions to put up so many flasks, but with no detailed advice as to gating or heading. Thus, jobs are put into production before the difficulties of the work are solved, and the result is that an unnecessary number of castings may be scrapped because of the same defects.

The gating of each individual job presents features peculiar to itself, and it would seem as though lack of attention to this detail is the cause of many waster castings. If the method of molding is worked out before the job is put into production, several corrections may be made after each experimental casting is poured, and much scrap can thus be eliminated. When the molding has been worked out, and the job is satisfactorily in production, a good casting can be photographed with the gates and risers attached, and such notes can be made that when a similar casting is called for later, a permanent record will be available. It should not be thought that experimental molding is necessary for every job brought into the shop; if this were so, an endless number of records would be required. Most molders and foundry foremen must admit that they cannot rely upon memory as to the most suitable method of gating every type of casting, and that a permanent record showing the proper method of molding, gating, heading, position of chills, and so on, would be invaluable.

It has been pointed out above that losses in the production of aluminum-alloy sand castings vary markedly in different foundries depending upon numerous determining factors. While

*Traphagen, H.: The Value of the Scrap Pile, paper presented at the Philadelphia meeting of the American Foundrymen's association, 1919.

studying the problems involved in ascertaining aluminum-foundry casting losses in the United States, numerous plants were visited by the writer for the purpose of examining the available production records, inspecting the daily production of individual castings, and investigating general conditions at different shops. The data furnished in the replies to the questionnaires were thus supplemented by observation of working conditions, and the visits served to clear up points of interest not fully brought out in the replies. The analysis made of the replies to the questionnaire, together with other data that show the trend of casting losses in the production of typical castings, is given briefly in subsequent paragraphs.

Standards Vary at Different Foundries

A detailed discussion of the conditions at the numerous foundries visited cannot be included in this paper, but it will be sufficient here to say that local conditions must invariably be carefully inquired into when studying the causes for casting losses. In variety of castings made, methods of melting, quality of supervision, adequacy of records, labor turnover, and so on, great differences were presented at the foundries visited. The indicated annual monetary losses have been calculated on the basis of the total output, average losses, and cost of scrapping a pound of casting.

A summary of the factors affecting these losses, together with other cognate matter, is shown in Table I. The casting losses indicated are those furnished by the different foundries; usually, the actual losses, as shown by the production records, were substantially higher, say about 2 to 3 per cent. It will be noticed in Table I that there is a tendency for casting losses to be higher with increasing output; this may be explained on the ground that it becomes increasingly difficult to supervise the work of larger numbers of men, although the tendency should be lower in large foundries than in small ones, because the former should be in a better position to command the services of a better quality of supervision. Taking the five foundries listed in Table I on the basis of a total annual output of 29,220,000 pounds of castings and an average castings loss of 9.4 per cent, the total monetary losses amount to $385.309.

Table I

MONETARY LOSSES AND OTHER ITEMS IN REPRESENTATIVE ALUMINUM FOUNDRIES COMPARED

Foundry	Total annual amount of metal melted	Total annual output of finished castings, pounds	Kind of castings made	Metallurgical control	Quality of supervision	Melting and molding equipment	Quality of records kept	Average casting loss %	Annual monetary loss
A	13,250,000	9,500,000	Crankcases, largely; some other automotive parts	Fairly good	Good	Modern, good condition	Fairly good	7.0	$89,382.
B	5,400,000	4,000,000	Miscellaneous automotive castings	Poor	Fair	Modern, good condition	Poor	10.0	$55,556.
C	4,500,000	3,000,000	Miscellaneous automotive castings	Good	Good	Fair	Very poor	8.1	$29,374.
D	1,420,000	720,000	Vacuum cleaner castings	None	Fairly good	Fairly good	Very poor	8.0	$15,652.
E	18,000,000	12,000,000	Miscellaneous automotive castings	Fairly good	Good	Modern, good condition	Good	14.0	$195,345.
Totals	42,570,000	29,220,000							$385,309.
Averages								9.4	

This shows in a specific way the magnitude of the losses in certain individual foundries. The estimated monetary losses of the country will be given later, and it will be first advisable to draw attention to the losses sustained in the production of various typical kinds of castings.

Casting Losses in Producing Typical Castings

The data given in Table II have been furnished by various foundries, being obtained from the existing production records at the different plants. An attempt has been made to verify the accuracy of these data by personal inspection of the daily production of different castings at these foundries. At best, it must be confessed that strictly accurate data with regard to casting losses are difficult to obtain, and the problem becomes complicated in a foundry making a wide variety of castings—as in a jobbing foundry. In justice to the foundryman, it is also to be pointed out that there is unquestionably an economic limit beyond which it does not pay to go in collecting scrap records.

Classifying Defective Castings

In classifying defective castings, particularly in foundries using a piecerate system of wage payment, it is convenient to divide defects into two broad classes: Allowable defects and not allowable defects. This means simply that if a casting is scrapped because of an allowable defect, the molder will be paid for it, but if it is scrapped because of a not allowable defect, the molder will not be paid. In some foundries, the molder may receive a certain percentage of the base rate pay for every casting produced, whether defective or perfect. However, it is customary to regard certain defects as allowable and some as not allowable, while other defects may be regarded as partly allowable and partly not allowable, because of the difficulty in deciding whether a defect is directly due to molding or to some other factors. Also, allowable defects may be regarded as not avoidable, or avoidable only with difficulty, and not allowable defects may be considered to be readily avoidable. Thus, in one of the foundries investigated (Foundry *A*), defects are classified as follows:

Table II

Summary of Casting Losses Incurred in the Production of Typical Aluminum-Alloy Sand Castings at Different Foundries

Kind of casting	Made in foundry	Number of castings poured	Number of castings accepted	Number of castings rejected	Number of allowable defectives	Number of not allowable defectives	Indicated average casting loss, per cent	Probable average casting loss, per cent	Principal causes for rejection
Motor-car crankcase	A	53,691	47,391	6,300	3,333	2,967	11.73	12.00	Cracks, crushed molds, and broken in handling and chipping
Motor-car crankcase	B	3,037	2,900	137	52	85	4.55	7.00	Sand and sand holes
Motor-truck crankcase	C	2,263	....	....	....	....	7.68	8.00	Core shifts and cracked in welding
Motor-car oil pan	B	5,029	4,636	393	80	313	7.43	10.00	Sand holes and chill blows
Motor-car oil pan	B	3,669	3,504	165	69	96	4.53	7.00	Sand holes and mis-runs
Motor-car oil pan	B	690	666	24	2	22	3.47	6.00	Sand and sand holes
Motor-car oil pan	C	1,698	....	....	....	....	11.74	12.00	Core shifts and cracks
Motor inlet manifold	B	545	336	209	193	16	38.25	40.00	Core shifts and core blows
Motor inlet manifold	C	1,838	1,762	76	....	....	4.13	6.10	Core shifts and cores set wrong
Differential housing	B	610	499	111	64	47	18.20	20.70	Core shifts and sand holes
Differential housing	C	874	....	....	....	....	27.42	27.50	Sand holes and core blows
Differential housing	C	554	....	....	....	....	27.51	28.00	.....
Change-speed lever housing	C	2,587	2,421	166	....	....	6.43	8.50	Core blows, core shifts, and mis-runs
Control-shaft gear housing	C	2,851	2,785	66	....	....	2.30	4.30	Cracks and broken
Carburetor body	B	1,989	1,861	128	87	41	6.44	9.00	Cracks, sand holes, broken, and core shifts
Carburetor body	C	564	527	37	....	....	6.56	8.50	Core shifts
Motor fan	C	1,569	1,497	72	....	....	4.59	6.60	Core shifts, core blows, and bad cores
Motor fan	C	5,114	4,944	170	....	....	3.32	5.30	Core shifts, warped, and cracks
Wheel-hub cap	C	1,928	1,831	97	....	....	5.03	7.00	Mis-runs, sand holes, and core shifts
Oil-strainer cover	C	2,749	2,522	227	....	....	8.25	10.25	Broken molds and sand holes
Bearing cap	C	4,017	3,751	266	....	....	7.12	9.00	Blows and sand holes
Cable conduit union	C	5,196	4,409	787	....	....	15.14	17.00	Core shifts, core blows, and sand holes
Averages							10.54	12.26	

Classification of Allowable and Not Allowable Defects in Castings in Foundry A

Allowable*	Not allowable**
Cracks	Crushed
Draws	Sand and sand holes
Inferior metal	Cope drop
Dirty metal	Run-outs
Broken on chipping	Core shifts
Broken on handling	Cores left out
Core blows	Cores set wrong
Wet chills***	Mis-runs
Broken cores***	Dirty cores
Core sand***	Core drop
	Wet sand
	Chill blows
	Hard and soft ramming.
	Chill drop
	Chill left out
	Bad molds
	Wet chills***
	Broken cores***
	Core sand***

*Molders are not charged with losses because of allowable defects.

**Molders are not paid for castings made which are rejected because of not allowable defects.

***Partly allowable and partly not allowable.

It is a question of considerable debate as to whether certain defects should be classed as allowable or not allowable.

Table II gives in summarized form the casting losses experienced at different foundries in the production of various kinds of aluminum-alloy sand castings. Owing to faulty and incomplete production records, some corrections have been made; every correction has been made, however, with the approval of the foundry superintendent at the plant concerned, so that the figures given may be regarded as reasonably accurate. Thus, in Foundry *B*, 2.50 per cent has been added to most of the figures to cover rejections on the molding floor, in the core-sand knock-out room, and after welding. In Foundry *C*, 2 per cent has been added to cover rejections at the band saw and in grinding. In both foundries, all of the rejections did not appear in the records, and the corrections applied were arrived at by determining the extent of the losses which were not recorded by the inspection departments. A fairly complete

record of the causes for casting losses in the production of a motor crankcase for a 6-cylinder automobile is available from the production sheets of Foundry *A*. The summary is given in Table III.

Table III

CAUSES FOR CASTING LOSSES IN THE PRODUCTION OF A MOTOR CRANKCASE*

Specific cause for rejection	Number of castings rejected	Average percentage of castings rejected, based on the total number rejected	Average percentage of castings rejected, based on the total number poured
Cracks	1257	19.952	2.341
Crushed	447	7.095	0.833
Sand	278	4.413	0.518
Cope drop	107	1.698	0.199
Run out	250	3.968	0.466
Mis-run	269	4.270	0.501
Core shift	518	8.222	0.965
Core left out	235	3.730	0.438
Core set wrong	260	4.127	0.484
Core drop	39	0.619	0.073
Core sand	434	6.889	0.808
Dirty core	60	0.952	0.112
Broken core	204	3.238	0.380
Core blow	179	2.841	0.333
Broken in handling	863	13.699	1.607
Broken in chipping	536	8.508	0.998
Draws	64	1.016	0.119
Wet sand	152	2.413	0.282
Chill blow	2	0.032	0.004
Chill left out	12	0.191	0.022
Chill drop	6	0.095	0.011
Wet chill	8	0.127	0.015
Bad metal	114	1.810	0.212
Bad mold	6	0.095	0.011
Totals	6,300	100.00	11.73

* These figures refer to the production of a crankcase for a six-cylinder pleasure car during about six months production. These data were supplied:

Number of castings poured	53,691
Number of castings accepted	47,391
Number of castings rejected	6,300
Number of allowable defectives	3,333
Number of not allowable defectives	2,967

As will be noted by reference to the figures given, the main causes for rejections are traceable to cracks, crushed molds, sand holes, run outs, mis-runs, core shifts, cores left out, cores set wrong, core sand, broken cores, core blows, broken in handling and broken in chipping. If the not-allowable defects are regarded as avoidable and the allowable defects are not avoidable, the figures are as follows: Out of 6300 castings rejected, 3333 were scrapped because of defects which could not be prevented, or prevented with much difficulty, and 2967 were thrown out because of defects which could be prevented. Expressed in per cent and based on the total number rejected, the figures are: Fifty-two and nine-tenths per cent rejected because of not avoidable defects and 47.1 per cent rejected because of avoidable defects. Based on the total number of castings poured, there was 6.2 per cent rejected because of nonavoidable defects and 5.5 per cent because of avoidable defects. In other words, the casting losses in this foundry could be reduced by about 50 per cent if the readily avoidable losses could be prevented.

Rejections because of defects in oil pans are largely for the same reasons as those in crankcases, while in manifolds, core shifts are likely to account for a considerable percentage of the losses; cold shuts may also be numerous in manifolds because of the thinness of the walls. Porosity and leaks in manifolds and carburetors may run high at times, but no figures are available for the inspection of these castings for such defects. Inspection for porosity ordinarily is carried out during a special test for this defect. The average indicated loss in the production of a variety of automotive castings, as shown in Table II, is 10.54 per cent, with a probable loss of 12.26 per cent.

Losses in the production of various kinds of castings, as reported to the bureau of mines, by foundries unable to segregate the causes for rejections, vary widely; some of these may be properly regarded as merely estimates. The following figures for losses may be cited: One and 30 one hundredths per cent to 10 per cent, with an indicated average of 3 per cent for motor starter and ignition castings; from 7 to 18 per cent

Table IV

Relation of Total Annual Output to Casting Losses

Reply Number	Total annual output in pounds of castings	Kind of castings made	Casting loss, per cent			Kind of castings which yielded high and low casting losses	
			High	Low	Average	High loss	Low loss
111	12,000,000	Automotive castings including crankcases, oil pans, manifolds, transmission cases, etc.	20.0	8.0	14.0	Oil pans	Transmission cases
409	9,500,000	Crankcases mainly	14.0	3.0	6.5	Crankcases	Crankcases
594	4,000,000	Automotive castings, all kinds	18.0	3.0	12.0	Manifolds	Bearing holders and caps
523	3,000,000	Automotive castings, all kinds	24.0	3.0	11.0	Manifolds	Foot boards
490	2,205,640	Automotive castings	....	....	3.5	Crankcases	Crankcases
292	1,000,000	Automotive castings, crankcases, housings oil pans, magneto parts	20.0	4.0	11.0	.....	.....
472	780,000	Vacuum cleaner castings solely	11.0	5.0	8.0	Nozzles	Bag couplings
248	250,000	Kitchen utensils, automotive castings, electrical-tool castings, motor housings	5.0	....	2.0	Automotive castings	Electrical tool castings
497	125,000	Cooking utensils	15.0	4.0	10.0	.....	.....
455	75,000	Pressure cookers	4.0	1.0	3.0	Pressure cookers	Pressure cookers
222	30,000	Pattern castings, ornamental castings	5.0	0.5	2.0	Pattern castings	Ornamental castings
147	23,000	Crankcases, oil pans inlet headers, fans, pumps, foot boards	25.0	2.0	10.0	Water pumps	Steering-gear cases and foot boards
438	20,500	Miscellaneous repair castings	7.0	1.0	5.0	Light work	Heavy work
343	20,000	Pulleys, electrical tool castings, patterns	6.0	1.0	4.0	Pulleys	Electrical tool castings
475	6,000	Naval work	10.0	0.09	4.0	.....	.....
114	4,300	Machinery parts, surveying instruments, street car fare boxes, few auto castings	75.0	5.0	25.0	Machinery and instrument parts	Street car fare boxes
102	4,000	Automobile steering wheel spiders; shields or wireless; pattern castings	....	2.0	5.0	Shields for wireless	Automotive steering-wheel spiders
461	3,931	Pump parts, automotive, vacuum cleaner, ornamental	26.0	15.0	25.0	Pump parts	Ornamental
496	3,751	Thermometer parts, time clocks parts	23.0	2.0	10.0	Light castings	Castings of uniform thickness
477	2,511	Machinery parts, vacuum cleaner parts	33.0	2.0	9.0	.....	.....
501	1,658	Naval castings; patterns	5.0	0.0	1.25	Small chunky castings	Castings of uniform shape
333	600	Small parts for navy work	2.0	1.0	1.0	Light open castings	Heavy solid castings

ı indicated average of 12 per cent for a variety of auto- castings; from 1 to 16 per cent, with an average of 4 ıt for sand-cast kitchen cooking utensils; and from 2 to cent with an indicated average of 11 per cent for vacuum castings.

ıe predominant causes for casting losses, as deduced he inspection of many castings and from the production s of various foundries are found to be traceable princi- o molding. Thus, the main causes which led to casting include sand holes, cracks, crushed molds, core shifts, lows, dirty cores, cores set wrong, and mis-runs. Of cracks alone may be properly regarded as difficult to t.

'hen the attempt is made to determine the relation, if any, n the annual output and the percentage of casting loss, difficulties present themselves, and it is not possible to any definite relationship. Generally speaking, in large ·ies, the production is rushed, particularly during the year when the demands of the motor industry were heavy, is is naturally conducive to high casting losses. In small as a rule, the rate of production is rarely so rapid, and r or moderate rate of production tends toward lower On the other hand, the large plants can afford to employ grade men in supervisory capacities, and can engage :al assistance, as well as maintain laboratory control; factors tend to reduce losses. However, a well-equipped ɔmpetently supervised small plant may expect to show losses than a similarly managed large plant, because it be- increasingly difficult to supervise the work of an increas- mber of men. It is, at the same time, unsafe to attempt eralize too specifically when comparing small and large because of the diversity of factors which influence losses.

able IV is a summary of a number of replies to the ques- ire, indicating the annual output of the individual plant; nd of castings made; the high, low and average casting ; and the kind of castings which yielded the greatest and ɔsses. The tendency is toward greater casting losses in rger foundries.

The relationship between the melting stock used for castings and the resultant losses is not at all definite, nor have the replies to the questionnaire been clear on this point. It is safe to say, in a general way, however, that the quality of the melting charge does directly affect the casting losses—the poorer the quality of the charge, the higher the losses. In casting No. 12 alloy, the practice in different foundries varies widely as to composition of the charge. Some plants use only primary aluminum pig, plus the necessary amount of rich alloy or copper, and foundry scrap originating in the plant; others use part secondary aluminum pig with the preceding charge. Some plants use primary or secondary No. 12 alloy pig mainly, while others employ scrap castings purchased from outside sources whenever possible. So far as there is any evidence of a standard practice, it is found that numerous large and small foundries make up a mixed charge composed of the following materials: Primary aluminum pig; secondary aluminum-alloy (No. 12) pig; 50:50 copper-aluminum rich alloy (the so-called hardener of aluminum foundries); and foundry scrap, originating in the plant and consisting of gates, sprues, risers and defective castings.

Other things being equal, high scrap-content heats are likely to give rise to heavier casting losses than heats made up with less scrap, but this should not be construed to mean that there is anything inherently wrong with the use of scrap *per se*. The trouble arises in using dirty scrap and scrap of unknown composition. In the average foundry, it is imperative to remelt all the foundry scrap originating in the production of castings, and heavy scrap (gates, risers and defective castings) is a highly desirable material for melting. One foundryman, at least, claims to be able to "tone up" inferior aluminum pig by a suitable addition of No. 12 scrap in the charge, and some foundries prefer to make up heats from scrap castings exclusively, provided they can obtain scrap of high quality such as scrap aeroplane-motor castings.

The majority of the foundries which have any considerable output, normally use from 20 to 80 per cent primary aluminum pig plus other melting materials, but some founders prefer to

use primary No. 12 alloy pig rather than to make up the alloy in the foundry. Moreover, it should be said that the condition of the primary and secondary metal markets will affect the kind of materials used in heats; purchases of melting stock may be made in anticipation of rising or falling markets under normal conditions, or of materials that may be temporarily obtained cheaply, and the foundry foreman is compelled to meit the material supplied. Plants which operate machine shops for machining aluminum-alloy castings, in addition to the foundry department, may send the borings out on toll to a smelter and have them pigged; such plants normally employ varying amounts of secondary No. 12 alloy pig in the charges.

It has been difficult to trace any definite relationship between the composition of heats and the resultant casting losses, but ordinarily melts properly made from primary metals will give rise to less losses on casting than those made from secondary metals. This statement should not be taken too literally, for the reason that there are grades of primary aluminum that are less desirable for casting than certain other grades of secondary materials, and the term "secondary" is not used to connot anything inferior to "primary."

Effect of Melting Ratio

The effect of the melting ratio upon casting losses in the production of aluminum-alloy sand castings is one which is often overlooked. While there may be a pardonable pride in low sprue returns, these are always secured at the expense of increasing the casting losses, and sprue returns in aluminum founding are necessarily high at best. If it is assumed for simplicity, that the melting ratio is taken as the *weight of metal melted* to the *weight of finished castings poured,* (exclusive of gates, runners and risers), it is possible to show that the casting losses, particularly in aluminum founding may readily vary directly with this ratio. No account of dross, oxidation and shrinkage losses is taken, because under normal conditions in a given foundry, these factors remain reasonably constant. Castings made in aluminum alloys are normally gated with wider gates and with larger, heavier and higher risers than is the case with brass and bronze. In the replies to the ques-

Table V

Melting Ratios and Casting Losses in Aluminum Foundries

Reply Number	Total amount of metal melted per annum, in pounds	Total amount of finished castings, per annum, in pounds	Indicated *a* annual sprue returns in pounds	Indicated *a* percentage of sprue returns	Melting ratio	Melting loss *c* pounds	Average casting loss *d* per cent	Total annual amount of castings scrapped, pounds	Actual sprue returns, pounds *e*	Actual percentage of sprue returns *f*
431	84,000	38,000	46,000	54.8	2.21	1,260	10.0	4,222	40,518	48.24
403	400	200	200	50.0	2.00	6.0	0.0	00	194	48.50
407	30,000	15,000	15,000	50.0	2.00	450	4.4	690	13,860	46.20
472	1,440,000	720,000	720,000	50.0	2.00	21,600	8.0	62,609	635,791	44.15
375	3,000	1,500	1,500	50.0	2.00	45.0	4.2	66	1,389	46.30
451	6,516,277	3,286,712	3,229,565	49.1	1.98	97,744	8.0	285,801	2,846,020	43.68
287	70,000	40,000	30,000	42.9	1.75	1,050	4.0	1,667	27,283	38.98
191	200,000	120,000	80,000	40.0	1.67	3,000	10.0	13,333	63,667	31.83
205	10,000	6,000	4,000	40.0	1.67	150	1.0	61	3,789	37.89
438	34,2000	20,500	13,700	40.1	1.67	513	5.0	1,079	12,108	35.40
442	3,200	2,000	1,200	37.5	1.60	48	5.0	105	1,047	32.72
475	9,503	6,000	3,500	36.8	1.58	143.0	4.0	250	3,107	32.71
490	3,478,50	2,205,640	1,272,863	36.6	1.58	52,178	3.5	79,997	1,140,688	32.79
111	18,000,000	12,000,000	6,000,000	33.0	1.50	270,000	14.0	1,973,488	3,776,512	20.98
114	6,100	4,300	1,800	29.5	1.42	91.5	25.0	1,433	275.5	2.52
400	12,750,000	9,000,000	3,750,000	29.4	1.42	191,250	6.5	625,668	2,933,082	23.00
222	42,000	30,000	12,000	28.6	1.40	630	2.0	612	10,758	25.61
498	5,000	3,751	1,249	25.0	1.33	75	10.0	417	757	15.14
497	165,000	125,000	40,000	24.2	1.32	2,475	10.0	13,889	23,636	14.32
333	500	400	100	20.0	1.25	7.5	1.0	4	88.5	17.70
293	18,000	15,000	3,000	16.7	1.20	270	3.0	464	2,226	12.59
455	84,000	75,000	9,000	10.7	1.12	1,260	3.0	2,320	5,420	6.45
Totals	42,949,680	27,715,003	15,234,177	....	....	644,246	....	3,048,175	11,542,256	.....
Averages	1,952,258	1,259,773	692,463	36.1	1.62	29,284	6.44	138,553	524,648	29.99

a. Includes melting loss and casting loss.

Wt. of metal melted

tionnaire, numerous foundries reported from 1.50 to 2 pounds of metal melted for every pound of finished castings produced. This really means that from 0.50 to 1 pound of alloy appeared in the form of gates, runners, risers and defective castings, and this figure also includes the melting loss due to oxidation and shrinkage.

If the melting loss be placed at 1.50 per cent for the purpose of calculation, and if the percentage of casting loss be taken as reported, a summary may be drawn up as shown in Table V. The indicated melting ratio for some 50 foundries was 1.60, which means that for every pound of finished casting produced, 1.60 pounds of metal were melted. The indicated melting ratio for the 23 foundries listed in Table V is 1.62. This is a fairly good check on the figures given in Table VIII regarding the consumption of melting materials. Thus, referring to the latter table; the total amount of material consumed was 103,837,000 pounds, of which some 25,000,000 pounds were foundry and other scrap, this may be regarded as constantly in circulation. Figuring 81,000,000 pounds of castings produced, the ratio is 1.60.

Casting Losses in Production

Data furnished in replies to the questionnaire regarding the average percentage of castings rejected for specific reasons varied widely, depending upon the type of castings made, the rigidity of the specifications, the reliability and accuracy of the records, and other factors. Taking the actual figures reported, losses were stated to range from 0.0 to 75 per cent of the castings poured. On the same basis, the average losses reported varied from 0.9 to 15 per cent, with an indicated mean of 5.21 per cent; the high losses varied from 2 to 75 per cent, with an indicated average of 14 per cent; and the low losses ranged from 0.0 to 15 per cent, with an indicated mean of 2.6 per cent. Table IV gives the high, low and average losses reported in the production of various kinds of castings.

Machine Shop Returns

Figures for the average percentage of castings returned from the machine shop to the foundry are of little value unless the cause for scrapping the casting upon machining is deter-

mined. Usually, itemized data in regard to this are lacking. A casting may be scrapped in the machine shop because of warpage, lack of finishing stock, internal blowholes and other foundry defects or because of machining errors. The latter has no relation to foundry casting losses, and in the former, proper inspection will usually keep castings out of the machine shop which cannot be machined because of inherent defects. Figures reported to the bureau of mines for machine shop returns varied from 0.0 to 4 per cent, with an indicated average of 1.57 per cent. In the production of castings for the Liberty motor, it was found that about 1 per cent of the castings sent to the machine shop had to be returned to the foundry because of casting defects; this figure refers mainly to crankcases and oil pans. An average figure for the percentage of machine shop scrap caused by actual casting defects may be placed conservatively at 0.80 for all kinds of castings.

Reasons for Casting Losses

The replies to one of the questions in the questionnaire as to the reasons for casting losses were exceedingly unsatisfactory in the main, indicating that records are not kept in any considerable detail, other than in the largest plants. Table III gives a summary of an analysis made of the production records of a large foundry devoted to crankcase production. Table VI is an analysis of the reasons for casting losses in a foundry making a variety of automotive and other castings, based on an annual output of 12,000,000 pounds of finished castings and an average casting loss of 13.92 per cent. In analyzing the figures given in Table VI, it is interesting to note that the greatest individual cause for loss is cracks, and this defect is one of the most difficult to eliminate since it may be due to one or a combination of causes.

Cope drops causing sand holes, and sand left in the molds due to improper cleaning, account for 1.83 per cent of the rejections. Misruns and run-outs resulted in a loss of 2.18 per cent. Breakage in handling is 1.76 per cent, a high figure, but breakage is normally high in large foundries where the castings are handled by cranes and the production is rushed.

Table VI

CLASSIFICATION OF CAUSES FOR DEFECTIVE CASTINGS IN A LARGE FOUNDRY

	Causes for losses	Per cent of castings scrapped	Totals
Due to cores	Cut through	0.75	
	Crushed	0.21	
	Broken	0.57	
	Set wrong or shift	0.41	
	Blows	0.12	
	Miscellaneous	0.24	
TOTAL		2.30	2.30
Due to molding	Blows	0.24	
	Drops or sand holes	1.83	
	Chill blow	0.10	
	Hard and soft ramming	0.47	
	Wet sand	0.15	
	Chill drop	0.15	
	Miscellaneous	0.28	
TOTAL		3.22	3.22
Due to other causes	Cracked	2.27	
	Cracked in welding	0.36	
	Broken in handling	1.76	
	Broken in welding	0.10	
	Broken in chipping	0.34	
	Broken in knocking out cores	0.17	
	Broken in trucking	0.02	
	Warped or not to gauge	0.46	
	Poured short	0.17	
	Mis-run or run-out	2.18	
	Faulty metal	0.34	
	Miscellaneous causes, not classified	0.23	
TOTAL		8.40	8.40
			13.92

In the classification of losses according to groups, as given by the analysis in Table VI, 2.30 per cent was scrapped because of core troubles such as cuts through, broken cores, cores set wrong, crushes, core blows and core shifts, of which the first three caused the heaviest losses. Rejections due to molding errors contributed 3.22 per cent of the total losses, of which

Table VII

REASONS FOR LOSSES IN THE PRODUCTION OF ALUMINUM-ALLOY SAND CASTINGS

Reply Number	Most serious difficulty considered to be	Average loss per cent	CAUSES FOR LOSSES, PER CENT										
			Blowholes	Cracks	Shrunk	Porosity	Over-heated melts	Faulty ramming	Wrong pouring tempera-tures	Pound short	Unsound	Inferior aluminum pig	Molding causes, not classified
102	Cracks	5.0	1.0	4.0	....	....	....	....	....	....	....	....	....
114	Shrinkage	15.0	1.0	....	10.0	4.0	....	....	....	....	....	....	..
142	Do not know	25 0	2.0	15.0	5.0	3.0	....	....	....	....	....	....	....
147	Molding and melting	10 0	....	....	....	....	7.0	3.0	....	....	....	....	....
153	Do not know	9 0	....	1.0	2.0	1.0	1.0	....	2.0	1.0	1.0	....	....
191	Shrinkage	10 0	....	....	....	....	....	....	5.0	....	5.0	....	....
204	Ramming	5.0	....	....	....	....	....	2.5	2.5	....	....	....	....
233	Shrinkage and porosity	3 0	....	....	....	1.0	....	1.0	....	....	1.0	....	....
248	Inferior aluminum pig	2 0	....	....	....	....	....	....	....	....	....	2.0	....
279	Shrinkage	5.0	....	....	2.0	....	....	1.0	2.0	....	....	....	....
287	Pouring temperatures	4 0	0 5	0.5	0.5	....	....	....	....	0.5	....	....	2.0
293	Shrinkage	2 0	....	....	....	....	....	....	....	....	....	....	2.0
333	Shrinkage	1 0	....	....	1.0	....	....	....	....	....	....	....	....
343	Porosity	3.0	....	1.0	....	....	....	....	....	....	....	....	2.0
407	Pouring temperatures	4.375	0.125	....	0.125	0.125	....	....	3.0	0.5	0.5	....	....
438	Pouring temperatures	5 0	....	....	....	....	1.0	....	2.0	2.0	....	....	....
442	Shrinkage	5.0	....	....	....	....	2.0	....	....	....	....	....	3.0
455	Inferior aluminum pig	3 0	....	....	....	1.0	....	....	....	....	....	1.0	1.0
472	Molding	8.0	1.0	....	....	0.25	....	....	2.0	0.25	....	....	4.50
475	Cracks and pouring temperatures	4.0	0.25	0.95	0.75	0.25	0.25	....	1.0	0.10	....	....	0.45
477	Ramming and molding	9.0	....	....	3.0	....	....	....	1.0	....	....	3.0	2.0
496	Shrinkage	4.0	1.0	....	....	3.0	....	....	....	....	....	....	....
497	Molding	10.0	....	....	....	....	....	....	....	....	....	....	10.0
498	Ramming and pouring temperatures	10.0	....	2 0	....	....	2.0	....	4.0	....	....	....	2.0
Averages		6 724	0.286	1.019	1.016	0.568	0.552	0.313	1.021	0.181	0.313	0.25	1.196

the greatest number of rejections were due to cope drops, sand holes and hard or soft ramming. The other causes were responsible for the remaining losses—8.40 per cent.

Table VII gives a summary of some of the data regarding causes for losses as reported in the replies to the questionnaire. As already indicated, these replies were, in general, unsatisfactory because of insufficient detailed data. Certain of the information supplied cannot be regarded as much better than guesses, and usually the statement was made that no records were kept or that the foundries did not know the causes for their losses.

Difficulties in the Production of Castings.

Information was sought in the questionnaire as to the most serious difficulties experienced in the successful production of aluminum-alloy castings. The replies varied considerably, and the most serious difficulties were ascribed to widely different items by different founders. Thus, the following items were mentioned: Prevention of cracks and shrinkage; proper tempering of sand; correct ramming; inability to obtain competent molders; regulation of pouring temperatures; prevention of overheating melts in the furnace; prevention of blowholes, porosity, and unsoundness; inferior aluminum pig and inferior aluminum-alloy pig received from the makers; prevention of dirty, drossy spots and hard spots in castings requiring polishing; correct gating, difficult to work out; tendency of aluminum alloys to crack; complicated core work on castings; coring large jobs; and melting practice.

Kinds of Cores Used

Core troubles are generally prevalent, and many of the casting losses are traceable to cores. The tendency in aluminum-foundry practice is toward the use of green-sand cores wherever possible because of the greatly decreased production costs which may be affected by their employment. Practice still is rather variable, some foundries using dry-sand cores exclusively for their production, while others use dry-sand cores only where necessary. Green-sand cores are used largely in the founding of large automotive castings as body cores for crank-cases, oil pans, and transmission housings, and green-sand

cores are used to an increasing extent in casting cooking ute sils. In vacuum cleaner work, dry-sand cores are general preferred.

In some foundries, green-sand cores are used for heav chunky castings and dry-sand cores for light, open jobs. Dr sand cores are used practically exclusively for some kinds automotive castings such as manifolds, pistons and carbureto and particularly on small complicated jobs which are diffic to run. Green-sand cores are employed where practical f large castings. No figures have been made available as to co parative losses in the production of castings using green sand against dry-sand cores, and ordinarily such figures can ha little meaning.

Melting Methods

Information with regard to the effect of different meth of melting upon casting losses was sought, but the data f nished have proved to be exceedingly contradictory. As matter of fact, comparative tests of methods of melting ver casting losses will be invariably beclouded by the many otl determinate factors which enter into the problem. Thus, so foundrymen employ open-flame furnaces of the tilting or rev beratory types and claim that such furnaces are entirely sa factory from the standpoint of casting losses, while oth claim that the only way in which they can keep their los low is by melting in iron pots. Melting methods for alumin alloys are now being studied by the bureau of mines, and it hoped to issue a report later in regard to this question.

Inspection and Salvage Specifications

Since casting losses are very markedly affected by rigidity of the specifications covering inspection and salv it is necessary to consider this phase of the question minu when studying casting losses. Uniform inspection specificati for all kinds of aluminum-alloy castings necessarily car exist, and it is obviously impossible to draw up such inst tions. Various inspection instructions have been worked by the larger foundries, and purchasers, such as motor c panies, have specifications covering the allowable defects

mitted in castings for use in automotive work. In the final analysis, the vendor foundry and the purchaser must decide to their mutual agreement as to what defects will be permitted in acceptable castings, and how serious a defect must be so as to cause rejection of the casting. Necessarily the variations permissible are wide. Certain defects in one casting may cause rejection, but in another casting they would be inconsequential or might admit of repair.

One of the additional items affecting casting losses is that pertaining to salvage. If a defective casting can be salvaged by some repairing such as welding or soldering, then the casting will be acceptable and no loss will accrue other than the costs necessary to effect the salvage. The comprehensive set of inspection and salvage specifications covering certain castings for the Liberty aircraft engine* may be mentioned as a broad code of instructions. These specifications were more rigid than those usually enforced for automotive castings in general, but they serve to show the trend in the inspection and salvage of the highest class of aluminum-alloy sand castings poured.

Welding and Soldering

The reclamation and salvage of defective aluminum-alloy castings by welding and soldering cannot be dealt with in this paper other than to indicate the relation of this factor to casting losses. Strictly speaking, welding should not be construed as affecting losses, but the fact must not be lost sight of that in welding, castings may be either repaired, thus reducing the apparent foundry loss, or ruined, by cracking for example, thus having no effect on the apparent foundry loss. The importance of welding in the reclamation of defective castings will be apparent from the subjoined table:

Indication of Number of Castings to Be Welded in a Variety of Automotive Parts After Pouring

Number of castings poured	Number of Castings first accepted	Number of castings totally rejected	Number of castings to be salvaged by welding
2093	1018	267	808

In the above, out of 2093 castings poured, about 51 per

*Bureau of Aircraft Production, Metallurgical salvage instructions on aluminum castings, Report No. 78, Oct. 30, 1918.

cent were at first rejected, of which about 39 per cent cou possibly be salvaged by welding.

Interpretation of Casting Loss Data

The problem of reducing casting losses in aluminur foundry practice is one which must be worked out in individu foundries, and steps for the purpose of lessening these loss should be taken by the light alloy industry. Sufficient has be said to demonstrate the fact that the subject of metal wast and scrap losses is important in a high degree to the econom interest of the country. In foundry work, the scrap fact should be considered in cost estimates, and it is courting troul to quote work at uniform pound prices without regard for t specific quantities and kinds of castings. The value of adequa casting records in reducing losses becomes apparent when analysis of such records is made, because it is only by d termining the main causes for losses, as shown by reliat data, that corrective measures can be applied.

Reliability of Records

In the final analysis, the reliability of the casting recor can never be any better than the reliability of the inspectc who make them out. The selection of the correct type man for the position of inspector will go a long way in assu ing accuracy in the casting records. Too often, unfortunate no attention, or but little, is paid to this matter, but a co petent inspector will be able to save more than twice his sala in a short time provided his services are utilized to the fulle advantage. The experience of the larger aluminum foundri which maintain adequate inspection departments, has been th a main trained as a machinist, and preferably one who h had some experience as a molder in addition, is the most d sirable type for an inspector. Such a man usually has su cient technical ability to serve satisfactorily as an inspect and at the same time, enough general education to make c reports in the desired form. Some executive ability and cc siderable tact are also necessary qualifications of the successf inspector, for he may be called upon often to settle min disputes in the shop.

The casting loss data furnished by the production reports should give a complete record of the causes for rejection of every casting poured. In the foundry itself, the greatest use may be made of such records in determining the causes for losses. By so doing, steps may be taken to prevent the continued occurrence of the same defects in the castings in future production, and casting losses (and consequently production costs), can thereby be reduced. In the present investigation, it has been found that not over ten concerns kept detailed records of the causes for losses. In the majority of the foundries, no records at all were kept; in others, the average casting losses were known but the records were not kept with a view to segregating the causes for losses; in others the detail was insufficient.

Interpretation of Records

The interpretation of casting loss data in the foundry must be made with due regard to the many determinate factors which affect the losses, particularly the kind and design of the castings and the method of molding. Properly kept and interpreted, casting loss records prove to be of great value in correcting defects in castings, and thus enable the foundryman to reduce losses.

Use of Records in Accounting

Costing in a jobbing shop is one of the most difficult phases of accounting with which the cost accountant has to deal, and inaccurate production records will never permit fair costs to be arrived at. Without going into a discussion of cost accounting here even briefly, it will be evident of course, that it is highly inaccurate to distribute the casting loss in a foundry at so much a pound over all kinds of castings, where the loss in the production of one type may consistently average about 1 per cent, and of another type as high as 10 per cent. Neither job will thus bear its true burden of the cost, and the production costs of either casting cannot be known. Under the present conditions of competition, scrap loss costs should be pro-rated to the individual kinds of castings, since otherwise work may be quoted too high and not secured, or quoted too low and cause financial losses.

It has already been made clear in the preceding paragraphs that the prevention and reduction of casting losses is highly desirable from the standpoint of the individual foundry because of the effect of high losses on profits. From the national standpoint, it is also essential that losses be reduced to a minimum, because the total monetary losses of the country mount to high figures. For the purpose of the present paper, melting losses, fuel losses, and machine-shop returns will be disregarded and figures for the probable monetary losses in the United States in 1919 because of scrappage of aluminum-alloy sand castings will be calculated on the basis of an output of 81,000,000 pounds of finished castings, an average loss of 10 per cent, and an average cost of $0.125 per pound of scrapped casting. The calculations are:

81,000,000	= total output, pounds.
10 per cent	= average casting loss.
$0.125	= cost per pound of scrap.
81,000,000	= 90 per cent of the actual castings poured, since 10 per cent was scrapped.
$\frac{81,000,000 \times 100}{90}$	= 90,000,000 pounds of actual castings poured to obtain 81,000,000 pounds of accepted castings.
90,000,000 X 0.10	= 9,000,000 pounds of castings scrapped.
9,000,000 X $0.125	= $1,125,000, the total monetary loss.

If the figure of 0.80 per cent for machine-shop returns because of foundry defects be included, then the total monetary loss may be placed at approximately $1,200,000. If the present average casting loss could be reduced 50 per cent, and this is possible by eliminating the occurrence of readily avoidable defects, a saving of at least $600,000 would accrue to the foundries of the United States.

Conclusion

The problem of reducing casting losses in foundry practice must be solved by each individual foundry, and the following suggestions are offered as being applicable: Adequate technical control of raw materials and tests of the manufactured castings; comprehensive casting-loss records which give the

reason for the rejection of every casting poured; close inspection of molds, before closing, by a competent mold inspector; daily conferences on the results of the previous day's work by the proper officials; and reduction of the labor turnover by application of known methods. Necessarily, local conditions will largely govern the immediate steps to be taken, but it is firmly believed that substantial savings can be readily effected in most of the foundries of the country by making efforts to reduce the present casting losses.

Discussion—Casting Losses in Aluminum Foundry Practice

MR. PANNELL.—Has Mr. Anderson arrived at any conclusions as to how castings losses might be modified by the mixture being poured?

MR. ROBERT J. ANDERSON.—Everybody knows that aluminum zinc alloys containing around 33 per cent of zinc or less are liable to crack in the molds and cause losses much more than No. 12, in fact No. 31 was developed from the old aluminum zinc alloy because an addition of copper in an aluminum zinc alloy will reduce cracking. Probably 90 per cent of the castings poured are made from No. 12 or related alloys containing from 5 to 14 per cent copper. I seriously doubt whether it is the best alloy to use. For many types of castings other alloys would not only be cheaper but would do just as well, if not better. The question of development of alloys in aluminum is one of the most important that is now before the industry and I believe the time will come when we will have to get away from No. 12 alloy on an economic basis and develop other ones which have superior physical properties and which may be cheaper.

MR. SLEATH.—Is there any difference in the kind of material used for chilling; that is are cast iron, aluminum or brass chills used? I understand some people use different kinds of material for chilling.

MR. ROBERT J. ANDERSON.—That is very true. I have noticed that they use cast iron, steel, or even aluminum for chills. I presume there would be different defects due to the different rate of conductivity of different materials but I have no information at all as to what it would be.

DR. PAUL MERICA.—There was a current idea that alloys containing zinc are more subject to cracking than those made with copper. I wonder whether the author has any definite impression concerning the relative susceptibility of an

alloy such as the British No. 5, containing about 11 per cent of zinc and 3 per cent of copper and our No. 12 to cracking in the molds or to subsequent cracking in service.

MR. ROBERT J. ANDERSON.—Two different points are involved; first, the actual cracking in the mold and second, deterioration in service. I have had no experience with casting the British No. 5 alloy that you mention. I think the alloy works all right as far as I can find out. As to deterioration in service, the impression in this country for a long time has been that the aluminum zinc alloys either disintegrate or crack, or otherwise fail to perform in service the way they should. I believe it is claimed that this is due to impurities in the zinc but I doubt very seriously whether there is any real, reliable information on the question at all and the whole thing probably ought to be very thoroughly studied.

MR. F. H. SHULTZ.—I had the pleasure of visiting a shop where big aluminum pans were being made. The pans were about 6 feet long and 2 feet wide and had a raise on the sides of about 4 inches. I noticed that many of the castings were cracked square in two, and that the foundry had not yet made a good casting. I suggested that the pattern-maker make three sprues about 3 inches in diameter, tapered. The molder who was ramming up the cope, was instructed to set one of them just about an inch or so inside of the cope and after the metal was poured, the plug was removed, permitting the metal to shrink. The casting was all right when taken from the sand. That is one way foundrymen can overcome losses in cracked aluminum. I make a great many aluminum plates and sometimes I have to resort to the same method, and I have always been fairly successful.

MR. C. H. BREED.—I want to ask about the relative amount of zinc which would crack with age and whether it would crack in casting. I remember one case that came to my attention a number of years ago of an alloy that contained about 16 per cent of zinc and 2 per cent of copper. These castings had been subjected to the climate for about a year and a half. They were light frames and at the end of a year and a half

they had changed shapes and grown so that they were hardly recognizable. This led to an investigation which showed that castings containing under 5 per cent zinc retained practically the same shape, but the high zinc castings either were badly distorted or badly cracked and that led to the use of castings that contained no zinc, or less than 5 per cent.

The Chairman, MR. G. H. CLAMER.—Yesterday a gentleman told me of an experience he had in connection with such alloys. He has noted the growth of castings for about three years, and he recently measured them and found they were still growing. I suppose that they will grow until they reach a state of equilibrium.

The Relation of Die-Casting to Foundry Practice

By Charles Pack, Brooklyn, N. Y.

The casting of metals in sand molds has been practiced commercially for a period approximating 200 years. Darby and Raumer were early pioneers in this art and made many castings, both in ferrous and nonferrous alloys. Although the modern foundry would astonish the artisans of the eighteenth century, the fact remains that the general principles underlying the modern foundry practice have changed but slightly during the last two centuries. The foundry has progressed, it is true. The molding machine has, to a large extent, taken the place of the hand molder; match plates have taken the place of the crude patterns of old; and melting equipment has been perfected and made more efficient. Intricate core work has been made possible by the development of new sands and binders. Notwithstanding these developments, the writer is of the opinion that progress in the art of metal casting has not kept pace with the rapid strides of progress that have been made in the other arts of manufacture during the past two centuries.

Many Seek Permanent Mold

The "permanent" mold has been the dream of every ambitious foundryman. This everlasting search for a permanent mold finds justification in the fact that nearly all castings produced in the sand foundry require more or less machining. It is evident that by the use of a metallic or other "permanent" mold, castings having greater accuracy, and requiring less machining, could be obtained.

It is interesting to note that the use of the metal mold antedates that of the sand mold by two or three centuries.

of developing an alloy of comparatively low melting point, but having strength and other physical properties comparing favorably with cast iron or brass.

Zinc Base Alloys Tried

This demand was partially met with by the introduction of a large number of zinc-base alloys. By adding aluminum and copper in varying proportions to zinc, alloys are produced that are comparatively hard and strong. The tensile strength of some of these alloys exceeded 40,000 pounds per square inch and the elongation of the alloy was controlled by the addition of varying amounts of tin.

It was mainly on these types of alloys that the die-casting industry was established as a commercial manufacturing process. Unfortunately many of these alloys were compounded with a healthy disregard for all metallurgical principles. The alloys were overadvertised and misrepresented. Many of them warped and disintegrated in service, thereby creating a strong prejudice against the use of die-castings that has tended to retard the growth of the industry.

A review of the situation confronting the die-casting industry in 1910, tended to emphasize the fact that in order to establish the process permanently, it must be extended to the alloys of aluminum and copper. Die-castings made from zinc, tin and lead base alloys had a useful but limited field of application. The demand for aluminum and brass castings having a degree of accuracy approximating that of the zinc die-casting, was apparent.

Experiment with Various Metals

The problem of developing a process for die-casting the alloys of aluminum and copper coincides with the problem that has engaged the attention of foundrymen for many years, namely, the development of the "permanent" mold. Whereas, the foundryman has been making aluminum and copper alloy castings in sand molds and has been trying to perfect the composition of his mold, the die-casting manufacturer has conducted his experiments with a steel mold

ever, it is safe to assume that the process will be gradually developed to include larger castings.

By the die-casting process, aluminum castings are now produced with a maximum variation of 0.0025-inch per inch of diameter or length. Holes having as small a diameter as 0.093-inch can be cast. Outside threads of moderate accuracy can be cast and where extreme accuracy is desired the cast thread may be sized with a suitable chasing tool.

Relative Cost of Die-Castings

The initial cost of producing a die is generally much greater than the cost of making the patterns or a match plate for producing the castings in the foundry. This factor eliminates the die-casting process from consideration when only a small number of castings are required. As a general rule, die-casting cannot be considered as a manufacturing process where less than 5000 castings are required.

FIG. 4—COMPLETE BOX TYPE BRUSH HOLDER FOR A CAR HEATING SYSTEM

ago. Despite the spasmodic advertisements appearing in the trade papers purporting to "have overcome the heretofore insurmountable difficulties in casting brass and bronze in metal molds," there is no indication at present that the sand mold is in any immediate danger of being replaced by the metal mold for the casting of brass and bronze.

The writer, in a paper read before the American Institute of Metals in 1914, outlined the necessary properties for a permanent mold material for casting brass and bronze. These properties summarized briefly, are as follows:

Requisites of Permanent Molds

A. *Heat Resistance.* Material must not scale or oxidize at temperatures of 1600 to 1800 degrees Fahr.

B. *Expansion.* Material must have a very low coefficient of expansion, since the unequal expansion induced by the severe service will otherwise tend to crack the material very rapidly.

C. *Elastic Limit.* Material must have high elastic limit, since otherwise the continued expansion and contraction of the surface will cause rupture of the material.

D. *Conductivity.* Low conductivity is desirable to enable the metal to fill the cavity of the mold without the use of excessive pressures.

E. *Strength.* Material must have exceedingly high tensile strength if small cores are to be cast. The writer has found in his experience, that ½-inch cores made from alloy steels (exceeding 100,000 pounds per square inch tensile strength) would break in service, due to the high shrinkage of the metal around the cores. The cores would score and the sharp corners were eliminated when less than 100 castings were produced.

The writer is of the opinion that a material meeting the requirements outlined above, is not available at the present time. In the absence of such material, the brass die-casting process must be classified with the foundryman's "permanent" mold, as merely a dream without any immediate prospects of realization.

Discussion—The Relation of Die-Casting to Foundry Practice

MR. H. J. ROAST.—Will it be possible to adapt the die casting to any alloy melting as high as 170 degrees Fahr., particularly when the alloy is of a very soft nature, say more of the hardness of lead when it is cold.

MR. CHARLES PACK.—It is possible to die-cast almost any alloy that has sufficient strength to be used as engineering material. The trouble has been we have not been able to do it. The reason is quite apparent when we consider that we have spent five years trying to develop a steel that would be sufficient suitable for commercially casting aluminum alloys at a melting point of 1200 degrees Fahrenheit. Even at the present time we find quite a number of difficulties with the best grades of steel obtained. As the melting point of the alloy increases the difficulty with the die materials increases in proportion and the problem today is to obtain a suitable material for a die that will stand up for a sufficient number of castings to pay the initial expenses of that die. There is no question it would be quite an advantage to be able to cast iron and any other alloy of high strength and other favorable qualities.

We made sample die castings from aluminum bronze as far back as 1910, somewhat over 10 years ago, and it is a very simple matter to produce good looking die castings, but after sometimes 50 or 100 castings are made, depending on the size of the core, the pin will break. There is a terrific shrinkage around the pin and the pin will break off or the sharp edges of the die will be worn away and at the present rate of diemakers' wages very few dies can be produced for less than $400 or $500 and that would mean a die for a simple piece. Some dies cost as much as $3000 to $4000. Unless that die can produce enough castings to pay for itself and unless it can produce castings every day without having ex-

cessive maintenance charges it is impracticable. It is very easy to show a good sample and many men have made up pieces to show good samples and have been able to get backing to start die-casting concerns. When they actually find the cost of producing that material and compare it with sand casting and machinery practice, they find it is not practicable.

An Improved Electric Brass Melting Furnace

By Carl H. Booth, Chicago

In these unusual days of soaring costs, even the most skeptical brass foundryman is being forced to investigate the electric brass melting furnace. He no longer can argue that electric melting is experimental; more than 200 successful furnaces are proof positive that this is not the case. Every increase in the cost of labor and fuel brings him nearer the day when he must decide to install some type of electric furnace, and while the saving in metal loss or shrinkage still is undoubtedly the most important item in favor of electric melting, present day conditions have brought to the front other advantages and economies which he cannot longer afford to overlook. The electric furnace has arrived; it offers the best solution at the lowest possible melting cost. A summary of its many advantages includes: A clean, reducing, non-oxidizing atmosphere; superior working conditions with excessive heat and furnace gases at a minimum; any range of temperature obtainable, with simple methods of control—using pyrometer if desired; metal losses reduced to the lowest limits; and low labor and upkeep costs.

This paper is devoted to a discussion of the Booth rotating electric furnace which is designed to meet the requirements for electric melting just outlined, and which has many distinctive features of its own. Records are now available from upwards of 20 successful installations of furnaces ranging in size from 250 pounds to 2000 pounds capacity. The results obtained indicate that the furnace is a universal type of equipment, capable of handling efficiently every type of copper alloy, whatever the nature and character of the material charged.

Fig. 1 is a line drawing showing the basic principles incorporated into the design of the furnace, and the simple

electrical connections required. From this it will be noted that the furnace is in the shape of a cylindrical drum, for all practical purposes almost a sphere. The author believes that from the standpoint of minimum radiating surface, this is the most efficient construction to employ. The doors are located at the axis of the shell where the electrodes enter the furnace. The pouring tap is located at one end, which leaves the cylindrical walls of the shell unbroken, permitting

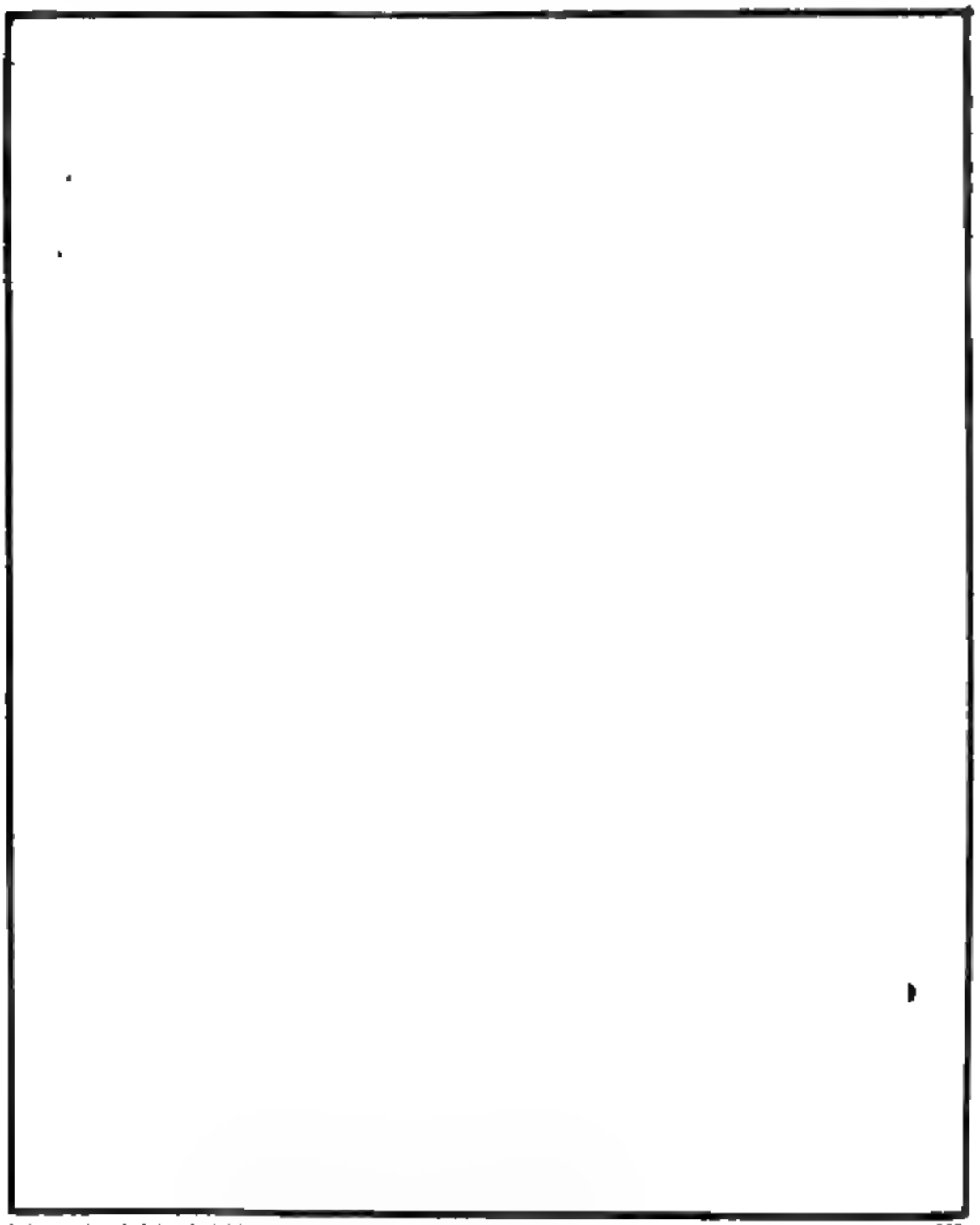

FIG. 1 DIAGRAM SHOWING BASIC PRINCIPLES OF FURNACE AND THE ELECTRICAL CONNECTIONS

complete rotation of the furnace. The electrical current is brought into the furnace by the moving contact method, similar to the third rail system employed in electric railway service. These distinguishing features result in a simple type of equipment permitting great flexibility in operating conditions.

All grades and types of copper alloys, ranging from sweepings, grindings and low grade foundry washings, up to the highest grade ingot metal and virgin pig, have been successfully melted in this furnace. The metals melted include pig tin, zinc, lead, copper, yellow and red brass of every variety of analysis, monel metal, and other high temperature alloys. Lead and tin drosses have been successfully treated, yielding a high recovery of pure metal at a low cost of operation.

The success of this furnace in handling such a wide range of products can largely be attributed to the application of the principle of rotation, which is accomplished by the special patented features and methods of construction referred to above.

Melting Yellow Brass Scrap

In melting yellow brass turnings and borings, which are difficult to handle in any type of equipment, especially when full of dirt, oil and other foreign matter, the furnace is loaded well up on the walls at either side of the electrodes. The door is then closed, one or both of the electrodes withdrawn to permit of the burning oil and moisture escaping, and the furnace placed in rotation. As the borings tumble around inside of the furnace, new surfaces are constantly exposed to the hot lining, and the oil and dirt is rapidly burnt out. (It is of course appreciated that the electric furnace is more valuable as a melting medium than used as a drying or oil-burning vessel, and if the constant run of material charged is very heavy with oil, it will soon pay in saving in furnace time alone to remove the greater portion of oil before charging. But the fact remains that, if desired, the foreign matter can be easily expelled in a simple manner before the actual melting begins.) As soon as the flame from the burning oil drops off, the rotation is stopped, the

electrodes inserted, the power thrown on and the melting started. The size of the charge will determine whether it is practical to commence complete rotation. If a maximum loading has been made, experience shows that equally good results can be obtained by leaving the furnace stationary for a brief period, and then advancing the shell forward occasionally to turn over the charge, finally going to complete rotation for 10 or 15 minutes before pouring. This method prevents any breakage of electrodes. If a smaller charge has been used rotation can be started immediately. The first method has the advantage in the using of the largest practical heats, resulting in the maximum daily output. The difference in metallic shrinkage, as between the two methods, is small.

The rotating electric furnace is especially adapted to treating or melting finely divided material. Metallurgists have known for years of the difficulty of getting borings, grindings, turnings and powdered products to coalesce and melt. Without complete rotation of the top layer of the material simply melts over, and each small particle of the charge seems to insulate against the passage of the heat, making it necessary to provide supplementary stirring, or secure the melt at a greatly increased loss. With the rotating action of the Booth furnace the charge simply *has* to turn over, exposing all particles to the heat, producing extremely rapid melting, and with low loss and power consumption. Since metals in this form can be purchased at the lowest possible cost, the furnace can show unusual economies when used on these grades of material. The demand for the furnace along these lines is rapidly opening up into many and varied fields, not only for melting purposes, but for important reduction and refining operations.

Recent records obtained from the Prime Mfg. Co., Milwaukee, on a 500-pound furnace of this type which is used almost exclusively for the melting of yellow brass turnings and borings, pouring directly into castings, are as follows:

Pounds melted per day (one shift)	3900-5500
Average daily output, pounds	4950
Average daily charge, per heat, pounds	550
Number of heats per day	8-10
Number of hours power on furnace daily	10-11
Average melting time, minutes	40
Time between heats, minutes	15-25
Average power consumption per ton, kilowatt-hours	300

Lining (made of good grade of arch fire clay brick) has lasted approximately 500 heats, and is good for many more.

Electrode consumption per ton metal, under 6 pounds.

No records as to net metallic shrinkage, exclusive of oil, dirt and moisture are available, but careful tests made on the same type and analysis of material in other Booth furnaces show that this need not exceed an average of 2 per cent.

Cleaning Prevents Short-Circuiting

In melting yellow brass turnings and borings, after each heat, generally between ladles, as only a moment's time is required, all live parts of the furnace are carefully cleaned off with compressed air, which we find prevents any short-circuiting due to deposits of zinc dust. The movement of the electrodes through the cooling collars is also tested out to see that they do not stick, and any loose slag left in the furnace after pouring the heat is removed.

The treatment of yellow brass borings being much the more difficult, the melting of other finely divided materials, such as red brass borings, turnings, skimmings, washings, etc., is very easily handled, with metallic shrinkage losses averaging not more than 1 per cent, and power consumption, even with a small size furnace like the 500-pound unit, averaging not over 350 kilowatt-hours per ton, operating only one shift per day, and including all preheating.

With heavier materials, such as heavy scrap, ingots foundry returns, etc., the practice followed is to hold the furnace stationary after charging until the metal has softened, then partial rotation is started, and finally complete rotation.

It has become standard practice with these furnaces, since it was early discovered that only a very limited time for preheating was required, to eliminate entirely the time usually consumed with heating up the furnace in the morning. Instead, where only one shift of 8 or 10 hours per day is

run, the furnace is charged at the end of the day after the last heat is poured for the first heat of the following day. Careful measurements with pyrometer showed that when the furnace was left empty over night, the temperature of the melting chamber in the morning had dropped to 450 degrees Fahr., but when charged the night previously, the temperature of the melting chamber the next morning was 900 degrees Fahr. This is good testimony to the efficient construction of the furnace, and the possibility of heat absorption and retention.

Data on 500-*Pound Furnace*

Records recently made on a 500-pound furnace at the plant of the Enterprise Brass Works, Muskegon, Mich., melting red and yellow brass for castings, in the proportions of about two-thirds red to one-third yellow, show what can be expected when using the furnace on heavy metal:

Average pounds melted daily	4800
Average charge per heat, pounds	600
Number heats per day—nine hours	8
Average power consumption per ton, kilowatt-hours	310

Records on the same size furnace at the plant of the Fulton-Harwood Brass Works, South Bend, Ind., indicate similar efficiency, although their daily average requirements for metal are less. The charge consists of virgin pig and local foundry scrap. Considering the fact that this furnace is not being pushed to its capacity, the showing made is exceptional, and proves clearly the ability of the furnace to operate on a low cost basis, even with a reduced day's operation. We quote from a recent letter:

"Below is a monthly report of the operation of your furnace in our factory from June 9 to July 9 inclusive, using new copper, tin, lead and zinc. Analysis, 85-5-5-5.

Metal melted, pounds	80,000
Kilowatt-hours consumed	14,761
Kilowatt-hours per ton of metal	370.8
Pounds of metal per kilowatt-hour	5.42
Cost of electric energy——per ton	$8.68
Electrode consumption, pounds	147¾
Electrode consumption per ton metal, pounds	3.7

Yale & Towne Mfg. Co., Stamford, Conn., recently completed thorough tests covering every phase of the operation of a 500-pound furnace at their plant. A high pouring temperature is required due to the light weight castings made, and likewise the time between heats is lengthened out since the metal is all taken in small pots. As a consequence it was necessary to keep the power on the furnace while pouring, which made the power consumption high and slightly increased the metal loss. There were other disadvantages in handling due to the location of the furnace, but when the practice in this foundry is thoroughly worked out much better records can be made. The analysis of the metal melted was: Copper 86.93; zinc, 9.62; tin, 1.86; lead, 1.38; and iron, 0.21 per cent. The summary of the test data is as follows:

Date 1920	Heats	Charge pounds	Melt time min.	K.W.H. to hold heat	Total K.W.H. used	Total time min.	Delay minute	Metal poured pounds
5/25	7	4060	317	69.8	712.4	552	7	*
6/1	5	3045	292	60.0	729.8	538	22	3007.5
6/7	4	2436	295	38.0	644.2	530	50	2391.0
6/8	7	4263	363	0.0	783.8	608	41	4209.5
6/14	6	3654	305	13.0	791.2	545	21	3620.5
6/15	5	3045	254	51.0	595.0	501	38	3010.5
6	34	20503	1826	232.6	4256.4	3274	174	16239.0
Average per ton.....			178	22.7	415.2	319	16.9	
Average per heat..			53.7			96.2	5.1	

*Box of gates missing.

Amount of metal melted in six working days, pounds	20,503
Number of heats	34
Average weight of heat, pounds	603
Total working time, hours	54.6
Average time per heat, minutes	96.2
Average melting time per heat, minutes	53.7
Average time between heats, minutes	37.4
Average metal melted per day, pounds	3,417
Average kilowatt-hours per ton	437.9
Average electrode consumption per ton, pounds	6.55
Gross shrinkage, per cent	1.24
Nonmetal in charge, per cent (approximately)	0.13
Net metal loss, per cent	1.11

*2.8-pound nipples.

Special notes regarding these tests made by the engineer referred to call attention to the fact that "the average quantity of metal melted per day, 3417 pounds in 9 hours and 6 minutes, or at the rate of 4000 pounds in 10 hours and 39 minutes,

does not give a fair estimate of the capacity of the furnace as the results were materially affected by the shortage of labor." Also, commenting on the average of 37.4 minutes required for charging and pouring, he says, "This 37.4 minutes was considerably longer than should have been required due to the nature of the charge, light scrap, and the shortage of labor. Under normal operating conditions, with regular men for carrying the metal, this time could be materially reduced, and the capacity of the furnace proportionately increased." The analysis made of metal before and after pouring showed that the loss was mostly zinc, and that the actual value of same was $2.45 per ton melted. Examination of the castings made from the metal melted in the furnace showed that there were no rejections due to the metal. With reference to the high power consumption shown, especially on June 1, 7 and 15, the statement is made that this was materially increased by the shortage of labor, as heats had to be held from 10 to 25 minutes until men were available to carry the metal, whereas the results of May 25 and June 8 show the increased capacity and decreased kilowatt-hours per ton due to elimination of these delays.

Figs. 2 and 3 show the 500-pound Booth rotating electric furnace at the plant of the Fulton-Harwood Brass Works, South Bend, Ind. Both front and rear views are shown.

Comparative Cost Per Ton of Metal

It is significant that even with a rate for power, in practically all of these plants, of at least 2 cents per kilowatt-hour, and occasionally up to 3 cents, the cost for electricity per ton of metal melted is no higher than present day costs for coke, coal, oil and gas. As the use of crucibles for melting is eliminated with the Booth furnace, and the total upkeep and repair costs on this small 500-pound furnace will not average over $2 per ton of metal melted—considerably lower than the cost of crucibles alone—the large savings made in metal losses and in labor show a margin in favor of the furnace.

The brass foundry needs small efficient melting units. The mixtures required in the day's run are quite varied. Large heats cannot be handled to good advantage for many reasons, but principally because of the difficulty in keeping the metal

FIG. 3 ANOTHER VIEW OF 500-POUND FURNACE

up to temperature, and the long shutdowns between heats. The records presented above show that it is practical to use a small arc furnace for intermittent daily operation and secure cost records almost as low as with larger size furnaces. The overall result is far superior due the greater flexibility in handling and the ability to make short heats; to follow one heat of a certain mixture with another heat of an entirely different analysis; to run, if necessary, only a few hours per day but not at a heavy penalty in cost; to use any grade of material from borings to pig metal; and thus to effect the maximum economy in metal used.

For the brass melter who has a large number of mixtures, or whose daily output is limited, a furnace of still smaller holding capacity can be obtained This is known as the 250-pound size. In all the details of its construction it is identical with the 500-pound furnace, and the power input is proportioned so that the same speed of melting results.

Foundrymen would naturally expect low costs in furnaces of large holding capacity, such as the 1000 and 2000-pound sizes, but the performance of the 250-pound furnace is even

more convincing proof that the principles embodied into the design of this type of equipment are sound.

A recent day's run on a 250-pound furnace at the plant of the Hill Pump Valve Co., Chicago, shows the following:

All Heats Were Red Brass 85-5-5-5

Heat No.	Power On	Power Off	K.W.H. used	Weight of charge pounds	Time between heats, min.
1	6:00	8:35	125	346	..
2	9:00	9:58	50	348	25
3	10:22	11:25	52	351	24
4	11:48	12:50	52	340	23
5	1:15	2:15	50	362	25
6	2:40	3:40	53	384	25
7	4:07	5:00	48	371	27
			430	2502	

Average power consumption—343 Kilowatt-hours per ton (no preheating required).

Notes:—

On each heat from three to five minutes taken to skim through door. Zinc added at this time.

Metal used: Old scrap copper (bearing blocks).

Pouring time: Ten to twelve minutes between heats.

Remainder: Clean electrodes and coolers, and charging furnace.

Leitelt Bros., Chicago, where one of these furnaces has been in operation for over a year and one-half, have an abundance of records showing equally as low results. Many heats on yellow brass scrap have shown as low a power consumption as 240 kilowatt-hours per ton, while on yellow brass turnings and borings, 210 kilowatt-hours per ton has not been uncommon. Linings have lasted almost 900 heats and none less than 600. This represents a cost of less than 10 cents per heat; conservatively 75 cents per ton. Accurate weighing of electrodes each day shows only 3½ to 4 pounds consumption per ton of metal, including breakage. Shrinkage has not averaged over three-fourths of 1 per cent on red brass, nor more than 1.4 per cent on yellow. Heats as small as 100 pounds have been made showing only a slightly higher average for all items than when run to rated capacity. The most efficient basis naturally is to charge a maximum of metal per heat, which for this furnace would be approximately 380 pounds.

Nordyke & Marmon Co., Indianapolis, Ind., is using one of these 250-pound furnaces for making difficult alloys and

the plant of the Michigan Smelting & Refining Co., Detroit, Mich.

These data show that the same speed of melting is obtained with the large furnace as with the small sizes previously discussed. Mechanical methods are being worked out so that the charging time will be cut down to a minimum, and practically all of the metal will be poured into one large ladle, and from that directly into the ingot molds. This means that it will be entirely practical to average one heat of the rated holding capacity of the furnace per hour. "Power consumption on the first heat of the day—2000 pounds red brass ingot—was 260 kilowatt-hours per ton, and took exactly one hour to melt," is a statement made in a letter just received. This foundry reports that some heats on the same material have run as low as 240 kilowatt-hours per ton. To date, however, due to the serious shortage of power in Detroit, and to labor troubles, this furnace has not been put into production, and a real statement of what it will do cannot be made.

Fig. 4 shows the 2000-pound furnace at the plant of the Michigan Smelting & Refining Co., pouring yellow brass after melting a charge of yellow brass turnings and borings, containing nearly 4 per cent of oil. Note at the left center the motor used for automatically controlling the operation of the electrodes. Fig. 5 shows the control panels for the 2000-pound furnace at the same plant, the one at the left being the electrode control panel. On the other panel shown, which is the standard furnace panel, note that not only a clock-type kilowatt-hour meter is furnished, but also an indicating ammeter, which has proved to be the best method for controlling the current.

Equipped With Automatic Electrode Control

This 2000-pound furnace at Detroit is the first electric melting furnace of the indirect arc, drum-type method of construction to be equipped with automatic electrode control. Before this was placed in operation it was freely predicted that such apparatus could not be used successfully, that the electrodes would stick and that there were peculiar short-circuiting conditions in the furnace caused by zinc and other metallic

prises the equipment. Either 220 or 110-volt direct current can be used.

One of the chief objections to the arc type of electric brass melting furnaces has been the higher labor cost required due to the necessity for hand control of the electrodes. This is overcome in the Booth furnaces by the automatic control of electrodes. In addition, the rheostat control feature offers a positive method for regulating the temperature which proves of great value when melting low temperature alloys, especially in the case of aluminum.

The possibilities of automatic control as regards ease in handling a battery of furnaces, may be likened to the methods now used in progressive plants with recording pyrometers in the control and regulation of heat treating and other similar furnaces. It does not take a serious stretch of the imagination to conceive of the application of much the same plan to the control and operation of a battery of Booth furnaces equipped with this practical and efficient device. On such a basis, the control panels for all the furnaces might properly be located at one central position, most convenient for constant observation by the melting superintendent. These would be appropriately numbered referring to the different furnaces in order. In conjunction with these panels would also be mounted the registering clock-type watthour meter and indicating ammeter, and a supplementary push button or starting box controlling the rotating motors for each of the furnace units. The melting superintendent could then easily take care of each furnace operation, much as a train despatcher handles trains, without the necessity of leaving his central position at any time. One or two assistants could supervise and help with the charging, leaving his entire time free for studying out the most efficient schedule for each heat.

Automatic Control Saves Labor

But whether one or more electric furnaces are used, in these days of high priced manpower, with common labor employed and hard to get at rates from 60 cents to 75 cents per hour, the addition of the automatic electrode control proves equally desirable, for a motor can control the flow of the cur-

rent better than by hand. Thus the furnaceman can be free to do miscellaneous work in the neighborhood of the furnace, including the preparation of the furnace charges, and frequently the cutting up of the gates and risers from the foundry scrap.

Attention should especially be called to the fact that no records are yet available showing what results can be secured when operating the different sizes of furnaces on a 24-hour schedule. The tests herein recorded are all on a basis of one shift averaging nine to ten hours, including all time for preheating.

It will be noted that the number of heats per 9-hour day averages eight on yellow brass and seven on red brass, in each case the charge being about 20 per cent heavier than the rated holding capacity of the furnace. This works out uniformly for all sizes.

It is also entirely practical, from these data, to make a reasonable estimate as to what the furnace will do on a 24-hour day schedule, if operated on the same basis of efficiency.

Eliminating from consideration the first heat of the day, and allowing an average of 25 minutes between heats, the data show that the 250-pound furnace would have a total daily output of at least 6000 pounds, and an average power consumption of 285 kilowatt-hours per ton on red brass and 235 kilowatt hours per ton on yellow brass. With the 500-pound furnace, the output would reach 12,000 pounds, and the average power consumption on red brass would run 275 kilowatt-hours per ton, and on yellow brass 225 kilowatt-hours per ton. The 2000-pound furnace should show a daily output of 48,000 pounds, with an average power consumption on red brass of 250 kilowatt-hours per ton, and on yellow brass of 210 kilowatt-hours per ton.

No 1000-pound furnaces have yet been placed in operation, although a number have been shipped, and results soon will be available.

Moving Contact Method of Carrying Electricity

There are many distinguishing features about the Booth type of indirect arc furnace, wherein it differs from other

equipment, but time will only permit a brief reference to the more noteworthy details. The two one-piece heavy metal tracks on which the melting chamber revolves are specially designed strong castings with ample cross-section, in the 250 and 500-pound sizes, to carry all the electricity required for melting the metallic charge. In all sizes above 500 pounds in holding capacity, two additional copper rings, completely encircling the melting chamber, are provided to carry the electricity, and in these sizes no current flows through the tracks. In both cases the current carrying members are insulated from the furnace shell so that no leakage can occur.

Between the two rollers on which the tracks rest, to the front and rear ends of the drum, two shoes, or contact surfaces, are located, pressing at all times closely against the tracks, or collector rings, held always in position by a strong adjustable spring. The cables or busbar from the transformer come through conduits in the floor to a point approximately in the center of the floor under the furnace, and from there spread out to the terminals of the shoes on either side. The position of the shoes, on all sizes, is purposely placed back from the ends of the drum, so that nothing can spill on them, or interfere with making a good electrical connection. This contact method requires practically no upkeep, as compared to the use of swinging cables. Either shoe of the pair is of ample capacity to carry the full current.

Another feature which contributes to low upkeep cost is the elimination of gearing for rotating the furnace. The positive friction drive used has proved to be very efficient. The two rollers on the side next to the motor, provided for rotating the furnace, are connected by a common driving shaft, which is then connected to the motor through worm gear reduction, running in oil, and a flexible coupling. Grease cups are provided for all bearings. The shaft joining the idler rollers on the opposite side of the furnace runs through a bearing pivoted at the center, which insures that all the rollers engage uniformly with their respective tracks. The friction drive improves as the parts wear. There are no gears to strip, or racking action involving shut-downs and replacements.

No special foundation or setting is needed for the furnace. The rollers, gear reduction and motor, push button control and water connections are mounted on the one-piece cast iron base, which is designed of the proper proportions so that the charging door and pouring spout are at the correct height from the floor. Any flat, level surface, substantial enough to carry the weight of the furnace, is sufficient. Provision is made for foundation bolts for imbedding in concrete if desired. Because of the base being all in one piece, the erection of the furnace is greatly simplified, as is also the moving and setting up of the furnace in another location at any time.

Water Cooling

The only place where water jackets or cooling is employed is the point where each of the two electrodes enters the melting chamber. The cooling collar is made of welded steel plate, and sufficient clearance is allowed for the passage of the electrode so that it does not need to be machined. As a result little difficulty is had with sticking electrodes. One valuable feature of this steel collar is the ease with which it can be repaired. Any leaks developing can be quickly welded together. Special note should also be made of the fact that the electrodes enter the furnace through the charging doors, the opening of which provides a quick method at any time for removing a broken electrode or replacing a water collar. The water pipes leading to the collars are made part of the furnace mechanism, swivel and rotating joints being provided to take care of all movements so that there are no delays due to changing of water connections.

Furnace Lining is Simple

One of the special features of the furnace is the simplicity of the lining. Complete repairs can be made quickly, not more than 24 hours being needed from the time the last heat is taken until the new lining is in place and the furnace ready to run. In other words, no long or costly shut-downs are caused. Advantage is taken of the drum-type construction of the shell, so that by removing either end section by simply unbolting from the shell, the new lining can be quickly slipped into the place. This lining comes in only three or four pieces (in addition to

No special stirring of the molten metal is required in the ladle, as rotation produces a homogeneous metal, even in case of high lead mixtures. Where exceptional mixing action is required, special fluted linings are furnished.

The charging door of the furnace is located at the opposite end from the tapping spout. If a battery of furnaces is installed, it is a great deal more convenient and economical both in the labor cost and the handling of materials, to have the charging operations all carried on at one end of the furnace, entirely apart from the tapping and pouring. This also saves floor space, as the furnaces can be located very close together under this arrangement.

For use in rolling mills, smelting plants and foundries where elimination of double pouring is necessary, special tapping arrangements are provided for pouring direct from the furnace into molds, the pouring tap remaining stationary, and at a fixed point.

Interchangeability of Furnace Shells

The absence of overhanging cables and water connections makes practical the quick replacement of one furnace shell with another one of the same size. The entire operation will not require over 30 minutes, nor is it necessary to cool down the furnace. Melting time can be saved if the new shell has previously been heated to temperature by the use of an oil flame. This ability to change shells is especially advantageous when great flexibility in melting operation is important. Special switching arrangements and transformer connections can be provided to take care of change in power input if required. There is the further advantage that by making use of a number of different shells with only one furnace base, transformer, and electrical equipment, entirely different metals and mixtures can be melted without contamination of metal. As a result, extra furnace shells can be used not only to provide better conditions for melting all kinds of materials to meet special conditions, but also, in the case of installations of a large number of furnaces in one plant, it would be good economy to have

an extra shell on hand, completely lined, ready for instant use whatever the emergency might be.

It has been the purpose of the writer of this paper not to attempt an academic discussion of the principles entering into the construction and operation of this "improved type of electric brass melting equipment," but simply to show from actual operating records the efficiency and the exceptional flexibility of this furnace as indicated by short heats, intermittent operation, ability to melt all kinds of mixtures and analyses in whatever shape or form the charge, with an operating cost, whatever the condition, at a minimum.

Discussion—An Improved Electric Brass Melting Furnace

MR. ST. JOHN.—I am particularly impressed with the importance of mixing metal during melting in all grades of brass and copper alloys. Not only does it give a more uniform temperature, and cuts down metal losses, but it gives a more homogeneous, a cleaner, finer quality of metal. In using high lead alloys containing 25 to 30 per cent lead, we have found that it is possible to pour metal from a furnace of the type without any additional mixing in the ladle, or in the furnace, with lead varying not more than ¼ of 1 per cent in most cases from the first to last metal poured. If the mixing action in the rotating furnace is equally as efficient as with the mixing action of the rocking furnace, I do not believe that the fluting lining is necessary. I believe he can get just as good mixing as is necessary without the use of a fluted lining.

I agree absolutely with what Mr. Booth says about the advantages of not preheating in the morning. It has been the practice of the users of the Detroit furnace, when we get through melting the last heat in the day, to put in the charge which we expect to pour the next morning and let it stand in the furnace over night. This avoids any necessity of preheating in the morning. The first charge in the morning takes possibly 20 to 25 minutes longer, but it certainly saves time and it certainly saves heat.

MR. BRAGG.—It seems to me that it is up to everybody to take some chance on the electric furnace question. The development of some castings, or melting, or anything else, depends on the number of people who get into it and get into it intelligently and the more who get interested in it and get started the better off we are going to be. Now I do not know anything that will develop the defects of any furnace quicker than the use of that furnace.

Taking as an example the year 1919, the cost of melting electrically in our plant, paying at that time an average of 0.8 per kilowatt was very nearly half that of the coke practice. I think our coke practice is quite below the average. We use No. 250 crucibles, which of course keep the melting cost down.

Carborundum Refractories in Nonferrous Metallurgy

By M. L. HARTMANN, Niagara Falls, N. Y.

While carborundum refractories have been used for many years in various types of furnaces used in nonferrous metallurgy, recent investigations have indicated that their usefulness and economy are even greater than is generally known. For this reason it seems desirable to call attention to the developments in the use of carborundum products for refractory purposes, especially in nonferrous metallurgy.

In order to have clearly in mind the distinguishing properties of carborundum refractories, it may be well to briefly review the physical and chemical characteristics of silicon carbide: High decomposition temperature (2240 degrees Cent.), no softening nor transition temperature below decomposition, high thermal conductivity, low coefficient of expansion, great resistance to chemical action, and extreme hardness. Four types of carborundum refractories are manufactured: Recrystallized shapes, bonded shapes, cements, and firesand mixes.

The recrystallized shapes are composed entirely of silicon carbide, being held together by the intergrowth of the crystals. This material has all of the refractory properties of carborundum itself.

Properties of Recrystallized Carborundum

Composition, silicon carbide, per cent	98-99
Apparent density of brick	2.30
Porosity, per cent	28
Specific gravity	3.18
Tensile strength, pounds per square inch	1000-2000
Crushing strength, pounds per square inch	12,500
Specific heat 23 degrees Cent.	.162
Thermal conductivity average 600 to 1200 degrees Cent.	.021*
Specific electrical resistance at 25 degrees Cent., ohms per cm³	100
Specific electrical resistance at 1500 degrees Cent., ohms per cm³	1.6

Spalling, equal to best fireclay.
Abrasion, cold 1/25 best fireclay brick.
Abrasion, hot, ½ best fireclay brick.
*Gram calories per degree Cent. per cm.³ per second.

The second type of refractory is composed of carborundum crystals held together by a small percentage of highly refractory bonding material. Three varieties of this type are produced, varying slightly in properties. All of these are similar in properties to the recrystallized product but are slightly less refractory. Large and more or less intricate shapes, which are not possible in the recrystallized material are manufactured in bonded carborundum.

Properties of Bonded Carborundum

	A	B	C
Composition, silicon carbide...	Above 90%	Above 90%	Above 94%
Apparent density	2.45	2.52	2.60
Fusion point, degrees Cent....	Above 1800	Above 1800	Above 1800
Specific heat (23 degrees Cent.)	.18	.18	.18
Thermal conductivity (average from 600 to 1200 degrees)..	.019*	.019*	.019*
Specific electrical resistance 25 degrees Cent.	....	100,000 ohms/cm³	125 megohms/cm³
Specific electrical resistance 1500 degrees Cent.....	....	750 ohms/cm³	8500 ohms/cm³
Spalling, relative to best fireclay.	One-half	Equal	One-thirtieth
Abrasion, cold relative to best fireclay	One-twelfth	One-twelfth	One-twenty-fifth
Abrasion, hot, relative to best fireclay	One-tenth	One-fourth	One-tenth

*Gram calories per degree centigrade per cm³ per second.

As the principles of refractory engineering are developed, it becomes more and more evident that there is no cure-all for furnace troubles. Refractories must be prescribed for the particular application in question. A complete line of carborundum raw refractories in the form of wet and dry cements has, therefore, been developed in order to provide suitable refractories for the many kinds of furnaces. These cements are used for molding shapes directly in the furnaces, for laying up refractory shapes and for general repairing and patching. Some of these cements can be vitrified only at the highest temperatures, and consequently may not be used for installations in which only moderate temperatures are encountered. Others are made especially for lower temperatures and these would not be entirely satisfactory in the highest temperature work. In all these mixtures, however, the primary material, that is, carborundum, is of the greatest refractibility and the variation in properties can be made only in the bonding agent.

The firesand mixes are raw refractories intended principally for use in rammed up linings. Carborundum firesand is composed principally of silicon carbide together with possibly some silicon oxycarbides formed by the partial reduction of silica at the high temperature of the electric furnace. While firesand does not withstand the extremely high temperatures at which carborundum bonded and recrystallized refractories may be used, it has high refractibility in comparison with other types of materials used for furnace linings.

Requirements of Refractory Mix

For use in molding refractory linings in place in the furnace it is necessary to use with the carborundum firesand some material which will bind it together firmly at all temperatures encountered within the furnace. In order to secure the maximum service from a furnace lining, it is quite essential to prescribe a raw refractory mix which when burned will have great strength in all parts and sufficient refractibility in the hottest zone. Many clays, frits and other bonding compositions have been tried with more or less success but the most successful and universally used mixture consists of firesand, a refractory clay and sodium silicate or water glass. Suitable prepared mixtures for various purposes may now be secured, or the carborundum firesand in various degrees of fineness, without bonding material is available for foundrymen who prefer to make their own refractory mixtures.

It has been found that the proportions of the different sizes of particles have important bearings upon the strength, texture and refractibility of burned firesand refractories. In the prepared mixes which have been placed upon the market, the sizes of particles have been carefully standardized, the most satisfactory clay has been selected and the proper amount of sodium silicate for the particular installation in question is furnished, so that, unless a foundryman has had considerable experience in the use of carborundum firesand it is probably safer and more economical to use the recommended prepared

mixture. These raw refractory compositions represent the best possible combination as determined by extensive experiments and commercial installations.

Applications of Carborundum in Crucible Furnaces

Many of the applications of silicon carbide refractories have been standard practice for a number of years. This is particularly true in both gas and coke-fired crucible furnaces in which carborundum firesand has been used extensively in making rammed up refractory linings. This type of lining for crucible furnaces has numerous advantages. It is easy to install because the forms used in the ramming are simple and easily constructed. The lining is highly refractory. It is not slagged down by the ash from the coke, and clinkers are easily removed without injury to the lining. The inner surface is mechanically strong and withstands the severe treatment to which a coke-fired crucible furnace is subjected. In oil-fired furnaces, firesand linings are very resistant to the flame erosion, and the linings are not melted in the zones of local heating, which are encountered with both oil and gas flames. In one large installation of which records have been kept 650 heats per furnace has been obtained, and the furnaces are still in operation.

The decreased maintenance cost of rammed firesand linings is extremely important in keeping down costs per ton of metal. In some plants, the night and Sunday repair crew has been eliminated or reduced to a very few men.

There are applications in which it has been found advantageous to use refractory shapes in place of the rammed firesand linings. This, of course, increases the cost very considerably but is economical because of the decreased repairs and certainty of operation. For example, one brass foundry making large castings must have 20 crucibles of metal from coke-fired pit furnaces ready for the same pouring. They have adopted shaped refractories even at the higher cost, expecting to compensate for this by greater efficiency in operation.

In another instance, a comparative test was made of the merits of rammed cement linings and rammed firesand linings in oil-fired pit furnaces. Several linings of each kind were made and all run in the same way. While the cement linings lasted longer and required less patching and attention than the firesand linings, the additional service did not warrant the extra cost of the cement.

In many brass foundries it has been found advantageous to use one of the cements as a protective layer over firebrick linings. This coating is applied to a thickness of about ¾-inch and has been found to greatly increase the life of the furnace lining.

It is quite well known that refractory linings most frequently give way at the joints, and to remedy this carborundum refractory cements have been developed and used. In some cases the life of the furnace lining has been doubled by the use of the proper cement for laying up the bricks.

The prepared cements are also useful in general furnace patching. Many operators have discovered that crucibles do not stick to pedestal blocks coated with carborundum cement. Others have found that a handful of dry firesand spread over the pedestal block accomplishes the same.

Refractories for Tilting and Rotary Furnaces

In the various types of tilting and rotary furnaces for melting brass, the linings are subjected to severe mechanical as well as thermal conditions. By means of suitable forms, a firesand lining may be rammed in place, and burned in one piece in the furnace at low cost. Some remarkable service records have been made in these furnaces which were lined with firesand. For example, one brass foundry was able to get a maximum of only 240 melts from either fireclay shapes or clay ramming mixture. They have recently been using rammed firesand linings and have had 1400 melts on one furnace and similar records on others.

Sometimes a customer does not care to build his entire lining of carborundum, but prefers to use carborundum cement

as a furnace wash. For such purpose, the cement is applied with a stiff brush to a thickness of one-half to three-quarters inch. One such case has been reported in which the operator, by taking care of the linings in his furnace by frequently washing with carborundum cement, increased the life of the lining 10-fold. This remarkable increase in life was probably due to the fact that practically no attention was given to the fireclay linings. In another authentic case several furnaces have been operating for more than a year, with only slight repairs every three or four weeks.

Refractories for Reverberatory Furnaces

The refractories in a reverberatory furnace of the type used for reclaiming foundry scrap and for refining other scrap metals are subjected to the most severe conditions. The temperature attained is usually high above that at which fireclay bricks can be successfully used. Recrystallized carborundum bricks used in the arches, vertebrae and the lower courses of the sidewalls of one such furnace near Niagara Falls have increased the life of the furnace from six or seven heats per lining to a total of 54 heats. Even in this case the bricks were not destroyed. The piers at the throat of the furnace had been constructed of fireclay bricks, which gave way and allowed the arches to fall. In rebuilding this furnace, the entire throat as well as the vertebrae and roof have been built of carborundum bricks. These bricks have also been installed from the bottom to above the slag line because they have been found to resist the action of the lime fluorspar slag with more than usual satisfaction.

In another scrap-reclaiming furnace in the Chicago district, the carborundum bricks were used around the doors and burner ports, and along the slag line. These bricks have given satisfactory service for 12 weeks and are still in place. At the slag line there is considerable erosion but the longer life and the fact that continuous operation of the furnace is possible, makes them much more economical than fireclay.

The bottoms of a number of reverberatory furnaces for melting and final refining (where only slight amounts of slag

are encountered) have been built of bonded carborundum shapes and have given satisfactory service. It should be pointed out that carborundum products cannot be used satisfactorily where lead oxide slags are encountered. Lead oxide is one of the best agents known for the decomposition of silicon carbide.

An oil-fired Schwartz reverberatory furnace for melting aluminum was partly lined with recrystallized carborundum bricks in July, 1919. The particular advantage of carborundum in this installation was the freedom from slag adherence. With carborundum bricks, the slag was easily removed without injury. The furnace is still in operation, and the bricks are in nearly perfect condition.

There are numerous special applications of carborundum in furnaces used in nonferrous metallurgy, but enough has been given to indicate the nature of the applications. While the comparatively high first cost of carborundum refractory material has caused some restriction in its use, nevertheless the general experience of users has been that the economy and satisfaction of uninterrupted operation much more than compensates for this extra first cost.

Discussion—Carborundum Refractories

MR. JESSE L. JONES.—I would like to ask the speaker whether a recrystallized carborundum brick that is put in an arch fails from air cracks or oxidation, or some other way?

DR. M. L. HARTMAN.—The rate of oxidation of carborundum in an ordinary furnace is slow and so far as I know I have never heard of an arch failing, made of recrystallized carborundum.

MR. JESSE L. JONES.—Is there any tendency for the brittleness of the material to cause air cracks?

DR. M. L. HARTMAN.—There is a little trouble, but not nearly so much as in fireclay.

DR. PAUL MERICA.—I would like to ask the author about the resistance of carborundum to acid and to lime vapor. We have been using carborundum as a roof brick for a small arc type electric furnace and we operate the furnace with a lime slag. Apparently the roof slakes off at a rather slow rate with the formation of a grayish deposit which we have never analyzed. Inasmuch as the furnace is operating under reducing conditions it does not seem likely that it is silica and the thought occurred to me that it might be the action of lime vapors which affects the carborundum roof.

DR. M. L. HARTMAN.—We know that carborundum will not stand very long in actual contact with alkaline substances. The gray deposit, I believe, is a mixture of graphite, since you run under reducing conditions, and probably lime vapors themselves which are probably somewhat carbonized so as to get a mixture of lime, carbon and calcium carbide.

MR. W. G. MCGANNIS.—In getting 1400 heats from the furnace, what is the bond?

DR. M. L. HARTMAN.—Fire clay.

A MEMBER.—You say that carborundum is not as affected by lead oxide, would that be the case in the electric furnace if you had lead oxide present?

DR. M. L. HARTMAN.—Yes, I think the statement still holds, if you had a slag very high in oxide it would slowly wear away the carborundum. I think the rate of solution would be determined by the concentration of lead oxide in contact.

A MEMBER.—In the presence of salt or slag, would a reaction set in, would not the sodium cause trouble?

DR. M. L. HARTMAN.—I think that would cause very little trouble.

Pouring Temperatures As Affecting Casting Shrinkage and Solidity

By R. R. CLARKE, Springfield, O.

This discussion concerns chiefly those castings in which bulk is heavy or variable or the ratio of volume to surface high. Examples are a 6-inch cube, a 5-inch pin brass 12 inches long, a valve body, a flanged bushing, etc. In using the word shrinkage we observe the sense of drawing, sinking or receding of metal at its highest or heaviest casting vicinities or between the variables of bulk where the shrinkage is unusually strong and exceedingly local.

Briefly the propositions at hand are:

1. Shrinkage decreases as temperature rises.
2. Cleanliness and compactness advance with temperature.
3. A closely defined and dangerous limit intercepts a rising temperature, marking the activity of gases and oxides and making for a most distressing condition in the castings.
4. Hot pouring necessitates molding with that end in view.

Fluidity is Factor in Shrinkage

That shrinkage should decrease with temperature is an apparent contradiction, since expansion's law is to advance with temperature and measure a corresponding contraction in return to normal. No doubt the explanation rests in part at least on the greater fluidity enabling the metal to generate and transmit higher gate pressure, run the mold more searchingly and establish and maintain better communication between its parts.

The primary advantage of hot pouring is a clean, solid, unshrunken casting realized through a comparatively small gate easily removed. Instances could be cited where a change of gating practice and pouring temperature reduced the gate metal from 100 pounds to 20 pounds and cut down cleaning time and expense, melting loss, etc., correspondingly.

Additional advantages are the suppression of the hair line fracture, of gate pin holes, and the nullified effect of molding inconsistence to which cold metal is so peculiarly sensitive. Against a hard cope or damp core cold metal immediately rebels

and solidifies, preserving the effect. Hot metal contends against the condition and often prolongs fluidity beyond the activity of cause.

The hair line fracture is a modified form of recession deriving from unequal contraction and intensifying with erratic molding such as wet sand, hard ramming, sparse venting, etc. By our experience it seldom seriously attends hot pouring but to greater or less degree always emphasizes cold pouring.

Requirements of Hot Metal Mold

A hot metal mold requires sand rather dry, rammed hard, faced well, vented freely and clamped or weighted securely in pouring. Similar precautions should be taken against the burning in of cores.

The author's experience lends to the belief that within certain limitations there is a suggestion of identity between the running capacity of metal in light thin castings and its power to resist shrinkage in bulky castings or variables between volume, that the ability of metal at proper temperature to run a thin gate and light casting is at least an indication of its function at the same temperature to transcourse the same gate to a clean, solid, unshrunken bulky casting. Both experience and experiment contribute to this inference under certain limitations as previously stated.

Hot pouring and solid castings apply more directly to the more common copper-tin, copper-tin-lead and copper-tin-lead-zinc alloys as 90 copper 10 tin, 88 copper 10 tin 2 zinc, 80 copper 10 tin 10 lead, 85 copper 3 tin 5 lead 3 zinc, and weakens in those metals and combinations observing an unusually high contractive tendency. Among these are pure copper, monel metal, yellow brass, manganese bronze, aluminum bronze, tobin bronze, muntz metal and other high zinc mixes. A further striking feature of shrinkage is that new metals or combinations on first melting usually advance shrinkage beyond that of a succeeding manipulation. Metal melted and pigged and then remelted and cast or that representing part new, part remelt will usually express shrinkage less than all new metal cast on first melting.

High pouring temperatures are critical chiefly because of extreme oxidation and the occlusion and expulsion of gases resulting in porosity. They therefore call for extreme caution and high-powered judgment. Beyond the danger line metal has sometimes a curdled-milk appearance, sometimes a dull-colored surface crust and sometimes a wicked looking exhibition of the varying colors arising from the different constituents such as tin, lead, etc. Another phenomena of transgression, is a spattering or crackling sound as that of boiling slag. Metal at such temperature will often appear mushy and cold and consequently deceiving as to its temperature when judged solely on its appearance of fluidity. These are dangers we might state we have encountered mostly in air and oil melting. On the other hand, cold pouring by virtue of low fluidity weakens cohesion, strengthens metals' power to hold and include its dirt and dross and denies that gate pressure deriving from the hydrostatic principles.

Many actual cases could be cited in proof of these arguments, among them the casting of heavy valve bodies, trolley wheels, heavy pin brasses, large bushings, heavy gear wheels, brazing flanges, pressure castings and many others. These will be honored with full discussion in the informal presentation of the subject before the convention.

In concluding the author expresses his regret at being unable to furnish pyrometric rather than mere judgment values on the temperatures to which he has made reference throughout feeling that such definite information would greatly increase the value of his remarks. However, this information is foreign to his knowledge and experience and therefore, beyond his power to submit.

Discussion—Pouring Temperatures in Nonferrous Practice

The Chairman, G. H. CLAMER.—Mr. Clarke has referred to the matter of hot pouring. He has had to deal more particularly with the metal which is most treacherous in pouring hot, namely phosphor bronze. Phosphor bronze, as you all know, if poured on the hot side, will emit the sand, and that is something which has to be guarded against.

MR. SLEATH.—Mr. Clarke's methods and mine agree pretty well. In pouring hot, our metal is subject to air pressure and curious things sometimes happen. I have seen a ring similar to a packing ring, not more than ¾-inch thick, which split right in the middle and you could almost pull one ring out of the other. They were split down the whole length of the ring and when they were broken they showed a brownish black fracture, in fact the grains did not seem to be united at all. We experimented a long time to find out the cause of it. We took metal that was poured too hot and we poured into the crucible metal that was the same temperature, and every groove was split.

MR. G. H. CLAMER.—Was the alloy used of a fairly high zinc content?

MR. SLEATH.—Yes, we run pretty high on zinc—as high as 18 for ordinary brass, sometimes 20.

RUSSELL R. CLARKE.—Did you use a green or dry sand core?

MR. SLEATH.—We used a green core, but it did not make any difference. We have tried them both ways.

MR. RUSSELL R. CLARKE.—I had a lot of trouble with the same kind of casting. I changed the mix and poured the metal hotter than before and I believe I had better results.

MR. G. H. CLAMER.—Did you reduce the zinc content?

RUSSELL R. CLARKE.—Yes.

MR. G. H. CLAMER.—I found that condition prevalent mostly with alloys of high zinc content.

MR. PATCH.—From my experience in making bushings, I have found that I can correct the trouble entirely by the melting practice. The line in your packing ring is due to a separation of the crystals at the point where they are coated with oxide. If your metal is free from oxide, clean, and properly melted, you can pour at any temperature desired, depending on the casting, and get a perfectly sound casting, as far as your cleavage condition is concerned.

MR. RUSSELL R. CLARKE.—How did you melt?

MR. PATCH.—In electric and oil furnaces. We are perfectly satisfied that the cleavage line is entirely caused by oxide. If you examine your cleavage line with a microscope you will find that it is well covered with a complete coating of oxide and of course you know that the oxides are not going to take any one position in the casting. If the metal is poured hot enough so it can flow in the mold, it more or less disproves your conclusion. The temperature of your pour being high, you should not have had that all in one cleavage space. Therefore as the crystals grow from the two surfaces of the castings they form this cleavage surface, breaking away, because the oxide present makes them weak enough at that point, and they pull apart and give you this cleavage line.

The Chairman, MR. G. H. CLAMER.—I wonder if Mr. Patch has ever investigated to see whether the oxide film results from oxide initially in the metal or whether the crack really extends all the way to the atmosphere so that the crack first occurs and then is afterwards coated with the film of oxide.

MR. PATCH.—We carried on a series of experiments to determine the source of the oxygen, whether it came from gases in the mold, or whether it came from inadequate gates, which would cause the mold to fill and then oxidize and then refill again on top of that. All of the tests gave certain information, but the ultimate conclusion was that it was the result of bad melting practice.

MR. ROBERT J. ANDERSON.—Mr. Patch brings up some strong points that indicate that it is a very dangerous thing to arbitrarily say that unsoundness in casting may be due to a certain factor. For example, it may be due to hot or cold pouring. In zinc bronze it is well known that unsoundness can be due to either hot pouring or cold pouring, and other alloys you have to pour at rather a narrow temperature range to insure solid castings. There have been a few investigations carried out on that. One of them was described a number of years ago before the Institute of Metals by Carpenter and Allen. The question of furnace temperature was mentioned and also the relation of melting practice to defects in castings was taken up. I believe that the construction of furnace atmosphere determines casting defects very markedly. At the present time furnaces are supposed to operate on oxidizing, neutralizing, or reducing atmospheres, and probably no one knows what those terms mean. Reducing atmosphere is supposed to indicate a high C O atmosphere. I think it is very important to correlate the furnace atmosphere with the casting losses, or the appearance of the casting after poured. In other words, we might get some good castings, out of one kind of furnace and poor castings out of another, if all your other factors were the same. In short, it is rather an undesirable thing to offhand attribute any one defect to one particular factor, rather than recognizing all of them and recognizing the importance of determining the effects of the others.

MR. I. L. WALTHER.—I would like to ask Mr. Patch to indicate what is the danger point of high temperatures.

MR. PATCH.—It varies some with different alloys. I would very much hesitate to try to give the temperature for any alloys. We make an alloy, for example, of 89 copper 11-10 phosphorus, which we pour out and we try to keep it within 50 to 75 degrees. We do not take more metal from the furnace than can be poured in the molds available so that the last mold poured is not more than 40 degrees lower than the first mold poured. If we have large castings we take more metal; we take less metal in the ladle if we pour small cast-

ings. We start off at 1960 degrees. This can be governed closely if no zinc is present, but if you have an alloy that has zinc in it you are bound to read on your pyrometer the temperature of your zinc rather than the alloy. Therefore unless you have some factor for correction on your pyrometer reading you will have trouble. We use a number of pyrometers.

We do not read the pyrometer temperature on alloy containing very much zinc simply because the zinc there will fool you unless you use correction figures. If you take time you can do so, but if you are going to take time you cannot do it for daily practice. It would be simply an experimental proposition enabling you to determine the appearance of the metal alloys at a given temperature.

The Chairman, MR. G. H. CLAMER.—How do you overcome eating up the phosphor bronze in pouring it hot?

MR. RUSSELL R. CLARKE.—We do not overcome it all together. In a heavy casting like a pin brass, the first thing that I do is to get half new, half old sand, so that it has plenty of body. Then I get it dry, then sieve it on the floor (not on the pattern) and then, if it is a heavy or medium sized casting, it is rammed hard. However, I don't let them get within an inch of the pattern.

Ram it hard. After the pattern is drawn, face it well with plumbago, dry it, and clean it out well. That is practically all there is to do.

The Chairman, G. H. CLAMER.—I am called upon frequently to diagnose the trouble of defective castings and I agree thoroughly with Mr. Clarke that 75 per cent of the trouble is due to cold metal.

Producing Small Nonferrous Castings

By RAYMOND H. SULLIVAN, Stamford, Conn.

The object of this paper is to outline the problem of producing daily a large number of small duplicate nonferrous castings and to describe a method of solution. Many of these castings are machined for interchangeable components in the productive output of a large manufacturing establishment. The examples and illustrations which follow are taken from the practice in the brass foundry of the Yale & Towne Mfg. Co., Stamford, Conn.

Thirty Base Formulas Used

While this paper deals with the production of one particular article from the base metals to finished castings, the principle involved is typical of several thousand somewhat similar castings varying in shape, size and composition. Some 30 base formulae are used in the composition of the various castings, the composition depending upon the use of the metal in the finished product. The castings range from bronzes involving high tensile strength and a large percentage of ductility to clear, soft, high finish brasses and bronzes, where colors are the prime requisite rather than strength.

While the processes described are employed in quantity production, castings are not produced under continuous operating conditions, day in and day out; consequently the greatest application of semiautomatic or full automatic equipment, such as traveling conveyors or rotating tables, etc., for handling molds, cannot be utilized. It is fully realized that where small identical castings are produced day in and day out, year in and year out, a much more efficient method than described herein can be applied.

Orders Range from Two to Fifty Thousand Pieces

This description, therefore, is intended to show how production is obtained in a large foundry, with a large variation in output of small brass and bronze castings in quantities

him. The elimination of making scrap into ingots results in a very large saving.

The experiments thus far indicate that electric melting is considerably more economical than oil melting. In melting direct from the oil furnace into the molds the experiments indicate that electric melting saves about 38 per cent. When double melting is employed in using turnings, melting first into ingots, then ingots remelted with new metal, a gain of about 70 per cent is indicated by the experiments with electric melting.

In conclusion, the writer wishes to bring to the notice of the readers several factors which must be considered in the analysis of quantity production of nonferrous alloys. The problem of producing continuously quantity production of the same identical article is very different and much more simple than producing large quantities for a short period of time, with a variation of composition. In the former case greater application of automatic and semiautomatic devices can be applied.

Records Are Important

Too much emphasis cannot be made upon the importance of records, not only of composition and analysis, but records of production, output, backstock, losses, reclamation, output per molder, etc. Records to the production foreman or superintendent are a large factor in guidance in obtaining efficiency of operation. Efficiency of operation is the basis of low costs in production.

The conclusions to be drawn from the experiments of electric melting described, indicate that the trend of nonferrous foundry melting is rapidly leading to the adoption of electric melting.

No attempt in this paper is made to describe the various types of electric furnaces, as the writer believes that each particular foundry must make a thorough analysis of the various types of furnaces and systems of melting now offered by the manufacturers and by a process of elimination, determine upon the particular type or system best adapted to its product.

Present Status of the Electric Nonferrous Industry, with Special Reference to the Foundry

By Edwin F. Cone, New York

In presenting an analysis of the progress in the use of electricity as a melting medium in the nonferrous industry, it is possible in a paper of this character, compiled in the last few days from delayed data, to bring out only the leading facts and to present only a generalized statement. It is not deemed expedient to give detailed tables of the installations of each type of furnace. The data, however, as presented are based on information furnished by all the sellers of the various types of electric melting mediums now in use as of Sept. 1, 1920.

The last published data known to the writer appeared in *The Iron Age,* March 4, 1920. These showed that on March 1, 1920, there were in the United States 261 electric furnaces of all types operating or contracted for in the nonferrous industry. The progress since then has been remarkably rapid. The compilation of the data, as of Sept. 1, reveals the startling fact that the total now in the United States and Canada is 383 or an increase of about 47.50 per cent in only six months.

Twelve Furnaces in the Field

In this almost new industry which comprises the foundry, the rolling mill and other phases, there are now 12 different furnaces as distinguished by their names. These are the Ajax-Wyatt, the Baily, the Detroit rocking, the Booth rotating, the Rennerfelt, the Snyder, the Von Schlegel repelling arc, the Weeks, the Ludlum, the Greaves-Etchells, the General Electric muffled arc and the Northrup furnaces.

Taking up some of these individually, the Ajax-Wyatt, sold by the Ajax Metal Co., Philadelphia, is operating largely in the brass industry, particularly the rolling mill end of it.

On March 1, 1920, this furnace was credited with 118 installations; on Sept. 1, these had expanded to 176 of which about 45 are credited to the foundry field. This is an increase of 58 in six months. Beside these, the company selling this furnace has contracted for four for shipment to France.

The Baily furnace, sold by the Electric Furnace Co., Alliance, O., which may be recognized as the pioneer in this industry, now has to its credit 76 furnaces in the United States and two in Canada, in the nonferrous industry, with five sold to foreign countries; on March 1, this year, the total was 61 or an increase of 17 in six months. About 56 furnaces are operating in the foundry industry.

Last March the Detroit rocking furnace, sold by the Detroit Electric Furnace Co., Detroit, was credited with 44 furnaces in this industry; on Sept. 1, there were 49. Besides these, there is one making aluminum steel and one used in melting cast iron borings and steel scrap for piston rings in Detroit. Of the 49 Detroit furnaces, about 28 are credited to the foundry end of the business. The company has also sold one to France, three to Japan and one to England.

The Booth rotating furnace interests of Chicago announce the sale of 40 furnaces as of Sept. 1 of which about 16 are in foundries; last March the total was 20.

The increase in the case of the Rennerfelt furnace installations on Sept. 1 over those in March 1 is five, the total in the United States and Canada now being 14, of which one is in Canada. Of the present total seven are credited to foundry operations. The furnace is sold by Hamilton & Hansell, Inc., New York.

The company selling the Snyder furnace, the Industrial Electric Furnace Co., Chicago, is offering the Von Schlegell repelling arc furnace also. There are three of this latter in the nonferrous industry and one making aluminum steel. There are besides this, five Snyder furnaces now credited to the nonferrous industry in the United States as against seven in March

but the total of the two types is eight. Of these five are credited to foundry operations.

The American Metallurgical Corp., Philadelphia, is credited with one furnace, known as the Weeks. Of the distinctly steel melting or refining types there may be mentioned, the Greaves-Etchells and the Ludlum, each credited with one furnace operating in the nonferrous industry.

The General Electric Co. has in operation or contracted for nine furnaces known as the General Electric muffled arc furnace of which eight are in the casting industry.

On a small scale so far as weight is concerned there are now in use or contracted for commercial use, eight furnaces, known as the Ajax-Northrup, high-frequency, induction furnace of which one is making iron-nickel alloys. Besides these, there are about 20 furnaces of this type which are in use largely in laboratories but some of which are later expected to be turned to commercial use. These 20 are not included in these statistics.

Big Increase Shown in Six Months

Reviewing the foregoing and expressing the analysis of the data in the form of a table, we have the following as showing the total furnace of each type as of Sept. 1 and March 1, 1920, and an estimate of the proportion credited to the foundry industry.

	Total U. S. and Canada Sept. 1, 1920	Total U. S. Sept. 1, 1920	Total Canada Sept. 1, 1920	Total on March 1, 1920	Credited to foundry industry Sept. 1, 1920
Ajax-Wyatt	176	176	..	118	15
Baily	78	76	2	61	56
Detroit	49	49	..	44	28
Booth	40	40	..	20	16
Rennerfelt	14	13	1	9	7
Snyder	5	5	..	7	5
Von Schlegell....	3	3	..		
Weeks	1	1	..	1	1
Ludlum	1	1	..	1	..
Greaves - Etchells	1	1	..	..	..
General Electric..	9	9	..	..	8
Ajax - Northrup..	8	8	..	..	1
Totals	385	382	3	261	137

These data show that about 33 per cent of the total installation in the United States is credited to foundry operations. It must be remembered, however, that these figures are partly estimated because of inability to obtain exact data in all cases as to foundry as distinguished from other operations. The large majority of the foundry operations are in red and yellow brass; there are three furnaces making aluminum castings, four phosphor bronze and one manganese bronze.

Comparison with Electric Steel Industry

It is interesting to compare these data with those of the steel industry. Of the total electric furnace installation in the steel industry, and including metallurgical or ferroalloy furnaces, at least 50 per cent are assigned to the foundry industry—a decided contrast.

We feel that the effort devoted to the compilation of these statistics is well repaid in the surprising showing which they reveal—an expansion in six months of 124 furnaces or 47.50 per cent in an industry which is hardly more than three years old. The progress that has been made is a testimonial to the electrical engineering and metallurgical ability and initiative of the country and is prophetic of still more valuable and interesting results to come.

Present Status of the Electric Steel Industry, with Special Reference to the Foundry

By Edwin F. Cone, New York

The object of this paper is to present a general statement of the status of the electric furnace steel industry as of Sept. 1, 1920, without going into the details as to tables which *The Iron Age* brings out in its annual review number in January, and to show in particular the place the electric furnace occupies in the foundry industry. The data here presented in abstract are based on replies from all the companies selling such furnaces except one company which could not see its way clear to furnish even a general statement. The figures for that particular type therefore stand as of Jan. 1, 1920. The paper presents a comparison of the status on Sept. 1 and Jan. 1, 1920.

The steel industry as a whole has not made the phenomenal progress which has marked nonferrous industry. Evidently the peak in this important movement was reached during the war and the industry may be regarded as having established itself on a sound and slowly-developing basis.

According to the data referred to, there were in the United States and Canada on Jan. 1, 1920, 363 furnaces of all types installed or contracted for in the steel industry; on Sept. 1 the total was 374, or a net increase of 11 furnaces. The increase has been wholly in the United States, the total for this country now being 334 against 323 Jan. 1.

The Heroult furnace, as licensed by the United States Steel Corp., has increased its installations in the last eight months by eight furnaces. On Jan. 1 the total in the United States and Canada was 170; on Sept. 1, the total is 178 of which 18 are in Canada. Of this total 78, or a little over 40 per cent, are credited to the casting industry. The following

data, furnished by the Steel corporation, is of interest as giving a summation of the functioning of this furnace:

Furnaces used for making ingots	103
Furnaces used for making castings	73
Total	176
Furnaces melting old scrap	146
Furnaces refining molten metal	8
Furnaces melting or refining	14
Furnaces making malleable iron	5
Furnaces making low phosphorus iron	3
Furnaces melting ferromanganese	2
Total	178
Number of quarter-ton furnaces	1
Number of one-ton furnaces	9
Number of two-ton furnaces	22
Number of three-ton furnaces	35
Number of four-ton furnaces	2
Number of five-ton furnaces	1
Number of six-ton furnaces	93
Number of 10-ton furnaces	2
Number of 15-ton furnaces	7
Number of 25-ton furnaces	4
Number of 35-ton furnaces	2
Total	178
Total gross tons per charge	1035.25 tons
Average gross tons per charge	5.95 tons
Average net tons per charge	6.66 tons

The average charge of the 6-ton furnace is 14,000 pounds each. This type of furnace is the only one which is operating on large quantities up to 35 tons capacity.

The Industrial Electric Furnace Co., Chicago, presents a different classification of its furnaces than formerly: Snyder, multiphase and Von Schlegell repelling arc types. Of the Snyder there are now 22 in the United States and two in Canada; of the multiphase 16 in the United States and one in Canada, and of the Von Schlegell, one in the United States making aluminum steel. There are three of this latter type making nonferrous products. The total therefore as of Sept. 1 is 41, of which 39 are in the United States. Of this total about 33 are credited to the foundry industry. Two furnaces are credited to Japan and one to Chile.

The Rennerfelt furnace, as sold by Hamilton & Hansell, Inc., New York, is credited with 15 furnaces in the steel indus-

try on Sept. 1, of which about 10 are operating on castings. The company announces the development of its Rennerfelt electric reverberatory furnace.

On Jan. 1, 1920, the Greaves-Etchells furnace, as sold by the Electric Furnace Construction Co., Philadelphia, was credited with 18 furnaces in the United States and Canada; on Sept. 1 this total had expanded to 25. Of the latter total two are credited to Canada and about 19 to the foundry industry. Three furnaces for steel castings have been sold to South America, two to companies in Buenos Aires and one to the Chilean naval commission, of Chile. A new electric furnace for nonferrous products has been developed by this company.

There is one less installation credited to the Gronwall-Dixon furnace on Sept. 1 as compared with Jan. 1, the total now being 12, of which one is in Canada. Of the total six are operating in the casting industry. The John A. Crowley Co., sellers of this furnace, went into the hands of a receiver a few months ago.

The Ludlum furnace installations now number 11 or one less than in January and of the total about five are operating on castings. The company selling this furnace, the Ludlum Electric Furnace Corp., is operating nine special pot furnaces on metal and ferroalloys at Watervliet, N. Y., but they are not included in these statistics.

The installations of Greene electric furnaces have expanded from 11 to January to 18 on Sept. 1 and of these about 11 are in foundries.

Instead of four Vom Baur furnaces on Jan. 1, there are now five in the United States, all in the steel casting field. One was only recently sold to the Consolidated Steel & Foundries Co., Mexico City, Mexico, for castings.

The installations of the Moore or Pittsburgh furnace remain the same in this analysis as reported on Jan. 1 or at 20. Further details are not available.

There have been no changes, so far as ascertainable in the other types of furnaces except the addition of another Detroit

furnace, sold by the Detroit Electric Furnace Co., which is operating on making cast iron piston rings for the Ford Motor Co. This brings the total to two in the United States on Sept. 1.

Segregating the foregoing analysis in the form of a table we have the following as showing the total furnaces of each type as of Sept. 1, 1920, and Jan. 1, 1920, and an estimate of the proportion credited to the foundry industry.

	Total U. S. and Canada Sept.1, 1920	Total U. S. Sept. 1, 1920	Total Canada Sept. 1, 1920	Total U. S. and Canada Jan. 1, 1920	Credited to foundry industry Sept. 1, 1920
Heroult	178	160	18	170	78
Snyder & Co....	41	39	2	49	33
Rennerfelt	15	15	0	18	10
Greaves - Etchells	25	23	2	18	19
Grönwall - Dixon	12	11	1	13	6
Ludlum	11	11	0	12	5
Girod	5	5	0	5	0
Booth	12	12	0	12	6
Moore	20	20	0	20	15?
Induction	3	3	0	3	0
Webb	2	2	0	2	0
Stassano	1	1	0	1	1
Greene	18	17	1	11	11
Vom Baur.....	5	5	0	4	5
Detroit	2	2	0	1	2
Special	24	8	16	24	5
Totals	374	334	49	363	196

These data, besides showing a net increase of 11 furnaces in the steel industry in eight months, also reveal the fact that a little over 50 per cent is credited to foundry operations. This estimate is not accurate but is as near to reflecting actual relations as has been possible. Carrying the analysis a little further it may be said that there are about 175 furnaces making steel castings with five on malleable iron, two on aluminum steel castings, three on cast high speed tools and two on iron castings.

Contrasting the steel industry as a whole with the nonferrous, it is surprising to find that in about three years, the furnaces credited to the latter industry now exceed those credited to steel. On Sept. 1, the total in the steel industry was 374,

as against 385 in the nonferrous. The percentage of the latter total in brass foundries is about 33, as against a foundry percentage of 50 in the steel industry.

The magnitude of the electric furnace industry, from a melting and refining viewpoint, is not realized in its entirety except by the bird's eye view which such statistics give. To be sure they afford only the number of furnaces and not the output. A similar review of the electric nonferrous industry shows a total of 385 furnaces of all types installed or contracted for as of Sept. 1. The total with the 374 in the steel industry makes the total furnaces in the two industries 759 on Sept. 1. The impressiveness of this fact is emphasized when it is recalled that on Jan. 1, 1915, there were only 43 electric steel furnaces in the United States and Canada and probably no nonferrous furnaces. Of the 759 furnaces the United States is credited with 716. This country leads the world in this important industry and will doubtless continue to for many years to come.

Arc Welding and Cutting Practice for the Foundry

By A. M. CANDY, Pittsburgh

From the welding standpoint it appears logical to consider foundries as usually being in one of three general classes: (1) Those making castings exclusively for the trade; (2) those operated by and exclusively for large manufacturing organizations; and (3) those operated both for general trade and one or more manufacturing organizations. It is the writer's opinion that foundries in the first and third classes will of necessity be most exacting in requiring sound welds because the trade will be inclined to look upon a welded casting as being a second hand product until all interested parties are educated to the physical characteristics of good welds, and how good welds can be produced and verified by inspection and tests. (See bibliography.) It is the purpose of this paper, therefore, to discuss the various factors upon which good welding is dependent and to present physical data pertaining to good arc-deposited metal.

To discuss the various phases of the welding problem it is probably best to enumerate the many variable factors in the order of their relative importance, the first being considered the most important:

1. Physical and chemical characteristics of material proposed to be welded.
2. Welding education of supervisor or welding foreman. Also training and skill of welding operative.
3. Physical, chemical and electrical characteristics of electrode or metal to be used for forming the weld.
4. Physical and electrical characteristics of apparatus to be used for supplying welding energy.

The physical characteristics of arc welds and arc-deposited metal in which all foundrymen are primarily interested are entirely dependent upon the four factors cited above. Any one of these factors, if discussed fully, would warrant a paper of sufficient length to absorb all the time allowed for the subject today. To conserve space and time it will be possible to con-

atives for the arc welding and cutting processes. As a general rule the candidate has only a very few weeks at his disposal, therefore it is usually possible to give him only the underlying principles involving the mechanical manipulation of the welding tools and sufficient training to enable him to determine when a reliable weld is being made by inspection of the arc behavior, appearance of the deposited metal both when forming in the molten pool at arc extremity and by inspecting the deposits after being completed. (See bibliography.) In addition to these fac-

FIG. 4 SECOND STEP IN REPAIRING STEEL CASTINGS

tors the welding supervisor or foreman, especially in a foundry, should have a general knowledge of the behavior of various types of castings under heat He must know what types of defects can be repaired and must be able to recognize defects which are not susceptible to repair by welding. The judgment displayed by the supervisor in selecting repairable defects, arranging for the proper preliminary preparation of the parts to be welded, applying preheating where desirable in a proper manner, and annealing the parts after welding when necessary, together with the manipulative skill of the operative, determine the success of the welding applications. After having seen the exhibits of almost unbelievably poor welding work in the office

G. Pack, Chief Inspector of Bureau of Locomotive In-

spection at Washington, the writer does not believe it is possible to emphasize too strongly the necessity of training men to make skilled welders and competent supervisors.

For welding medium and mild steel castings by the metallic electrode process a bare wire electrode conforming with the specifications adopted by the American Welding society, as shown in the accompanying table, will be found amply satisfac-

AMERICAN WELDING SOCIETY

REVISED SPECIFICATION FOR ELECTRODE WIRE FOR ELECTRIC *WELDING IN CONNECTION WITH MILD STEEL

1—Chemical Composition:

	Per Cent
Carbon	—not over .19
Manganese	—not over .55
Phosphorus	—not over .05
Sulphur	—not over .05
Silicon	—not over .08

2—Sizes and weights:

Diameter fractions of inch	Diameter decimal equivalent	Pounds per 100 feet	Feet per 100 pounds
1/8	.125	4.16	2400
5/32	.156	6.51	1535
3/16	.188	9.37	1066

Allowable tolerance .006-inch, plus or minus.

3—Material—The material from which the wire is manufactured shall be made by any approved process. Material made by *puddling process not allowed.*

4—Physical Properties—Wire to be of uniform homogeneous structure, free from oxides, pipes, seams, etc., as proved by microphotographs.

5—Workmanship and Finish—(a) Electric welding wire shall be of the quality and finish known as the "bright hard" or "bright soft finish"—"black annealed" or "bright annealed" wire shall not be supplied.

(b) The surface shall be free from rust, oil or grease; a slight amount due to lubrication during last drawing being permissible.

6—Tests**—Electrodes must, before shipment or after delivery, show good commercial weldability when tested by an experienced arc welder. The electrode material shall flow smoothly in relatively small particles through the arc without any detrimental phenomena.

7—Delivery, Packing and Shipping—Electrodes shall be furnished in straight lengths of either 14 or 28 inches, put up in bundles of 50 or 100 pounds, as ordered. Each bundle shall be wrapped in heavy paper, securely wired, and marked on one end showing diameter in fractions of an inch, trade name and grade of wire.

Note:

*This wire may or may not be covered.

**If electrodes to above specifications sputter or flow unevenly, dip same in milk of lime (whitewash) before welding. This dipping may be done in quantity on stock on hand and allowed to dry, or welder may keep a pot of solution on hand into which the electrode is dipped immediately before welding.

duce electrode materials better suited to the welding of the various nonferrous metals and their alloys.

To determine the physical characteristics of (mild-steel bare-metal electrode) arc-deposited metal a 14-pound deposit was built up on a steel plate approximately ½ x 3 x 8 inches, the deposit being about 2 inches deep as illustrated by Fig. 1. Standard commercial practice was observed in this work, the operator exercising average care. No cleaning of the deposited layers was performed except by means of a stiff wire brush, no sand blast being used. Using only the deposited metal, two standard tensile test specimens were cut out as illustrated by Fig. 2. Other specimens also were obtained for compression, bending and shear tests. The results obtained were as follows:

Tensile Test

Test No.	Pounds per square inch Ult. strength	Yield point	Elas. limit	Per cent Elongation in 2 in.	Per cent Reduction in area
1	58825	41000	40000	8.2	19.9
2	54650	35000	29000	6.5	13.4

Compression Test

Test No.	Pounds per Square Inch Ultimate Strength	Elastic Limit
3	95,400	34,500
4	92,450	29,450

Bending Test: Bar, ½-inch thick was bent through an angle of 100 degrees around a steel rod of 1 inch radius.

Shear Test: Two specimens failed at 46,200 and 44,600 pounds per square inch respectively.

A deposit similar to Fig. 1 was built up but as each layer of metal was completed it was thoroughly brushed and sand blasted. Standard tensile test pieces were cut from the deposited metal which tested as follows:

Test No.	Pounds per square inch Ult. strength	Yield point	Elas. limit	Per cent Elongation in 2 in.	Per cent Reduction in area
5	56,075	35,875	29,000	16	23.4
6	58,225			18	27.8

The fractures had the appearance of high grade partially-annealed low carbon cast steel. It is interesting to compare tests Nos. 5 and 6 with Nos. 1 and 2 and observe that while sand blasting the layers of metal did not appreciably affect the tensile strength, it did improve the ductility of the

metal as evidenced by the per cent elongation and reduction of area. This is probably due to slag elimination to a greater degree. By close inspection of Fig. 1, one can see along the polished surface a scattering of relatively small imperfections. In the case of the sand blasted specimen, however, these are practically eliminated.

To give an idea of the physical properties of commercially welded cast steel, 10 steel bars, each 1 inch in diameter, were beveled and welded to obtain five welded specimens. The welded bars and also five bars of the original steel were turned into standard threaded test pieces similar to those shown at the right of Fig. 2. The results of these tests are as follows:

Welded Specimens

Bar No.	Pounds per Square Inch Ultimate Strength	Yield Point	Per Cent Elongation in 2 inches	Per Cent Reduction in area
1	57,100	30,600	10.0	21.8
2	54,200	29,700	7.0	14.7
3	45,000	27,600	5.0	14.7
4	51,200	30,700	8.0	14.7
5	55,700	32,200	9.0	18.6
Average	52,640	30,160		

Original Nonwelded Specimens

6	63,000	35,800	36.0	56.9
7	64,000	37,300	35.5	58.3
8	61,400	35,800	36.0	58.3
9	63,000	36,300	36.0	57.7
10	61,400	35,800	31.0	58.3
Average	64,560	36,200		

If we consider the average values of yield point and ultimate tensile strength, the welded specimens developed about 81.5 per cent of the ultimate tensile and 83.3 per cent of the yielding strength of the unwelded original steel castings.

Figs. 3, 4 and 5 show the various stages of a steel casting which was found defective due to large sand pockets. The entire defective part was cut out with the graphite electrode to fit the rectangular steel block which was then set in place and welded in position, using the graphite electrode process.

Where iron castings are to be repaired in the case of an extensive break, particularly if the grain is coarse, it is cus-

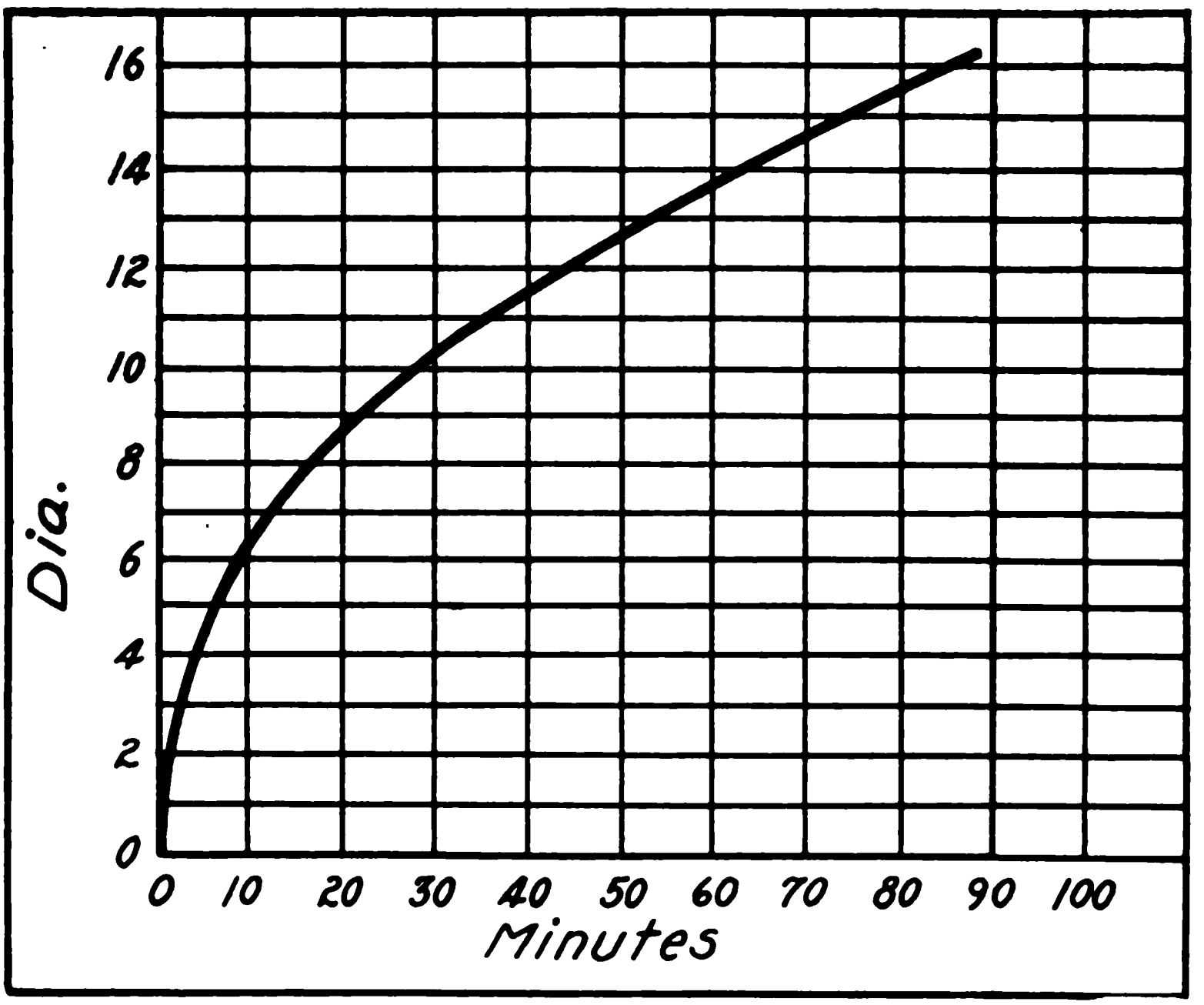

FIG. 13—RATE OF CUTTING CIRCULAR CROSS SECTIONS OF CAST IRON BY THE ARC PROCESS

any equipment available. However, he will observe after working with various welding outfits that it is easier for him to make good welds consistently, at greater speed and less expenditure of nervous energy with some equipment than with others. To provide for this condition the design and construction of the electrical equipment must be such that the following characteristics prevail at the arc:

1. Arc must be easy to start.
2. Arc must be easy to maintain.
3. Arc must produce sufficiently deep fusion or penetration in surface of casting or parts to be welded.
4. Current through the arc should remain practically constant at any value of arc voltage drop between limits of 20 to 0 volts.

Undoubtedly the best way to determine the existence of the first two characteristics is to actually work with various equipments under identical conditions, using the metallic electrode

FIG. 14—RATE OF CUTTING CAST IRON BLOCKS BY ARC PROCESS

process However, these characteristics can be illustrated by means of the oscillograph, as will be pointed out later.

Arc welding outfits are available in single-operator and multiple-operator types. The former type is illustrated by Fig 16, the scheme of connections is shown in Fig. 17, and the volt-ampere characteristic is indicated by Fig. 18. This equipment

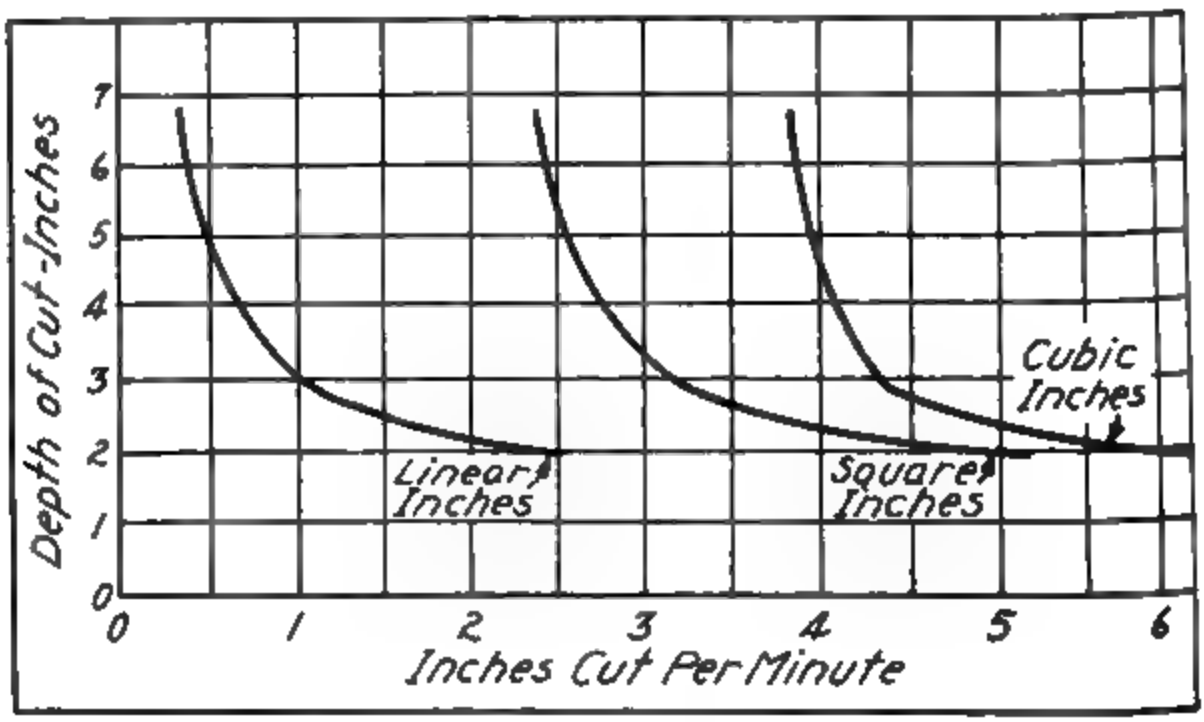

FIG 15—RATE OF CUTTING CAST IRON PLATES

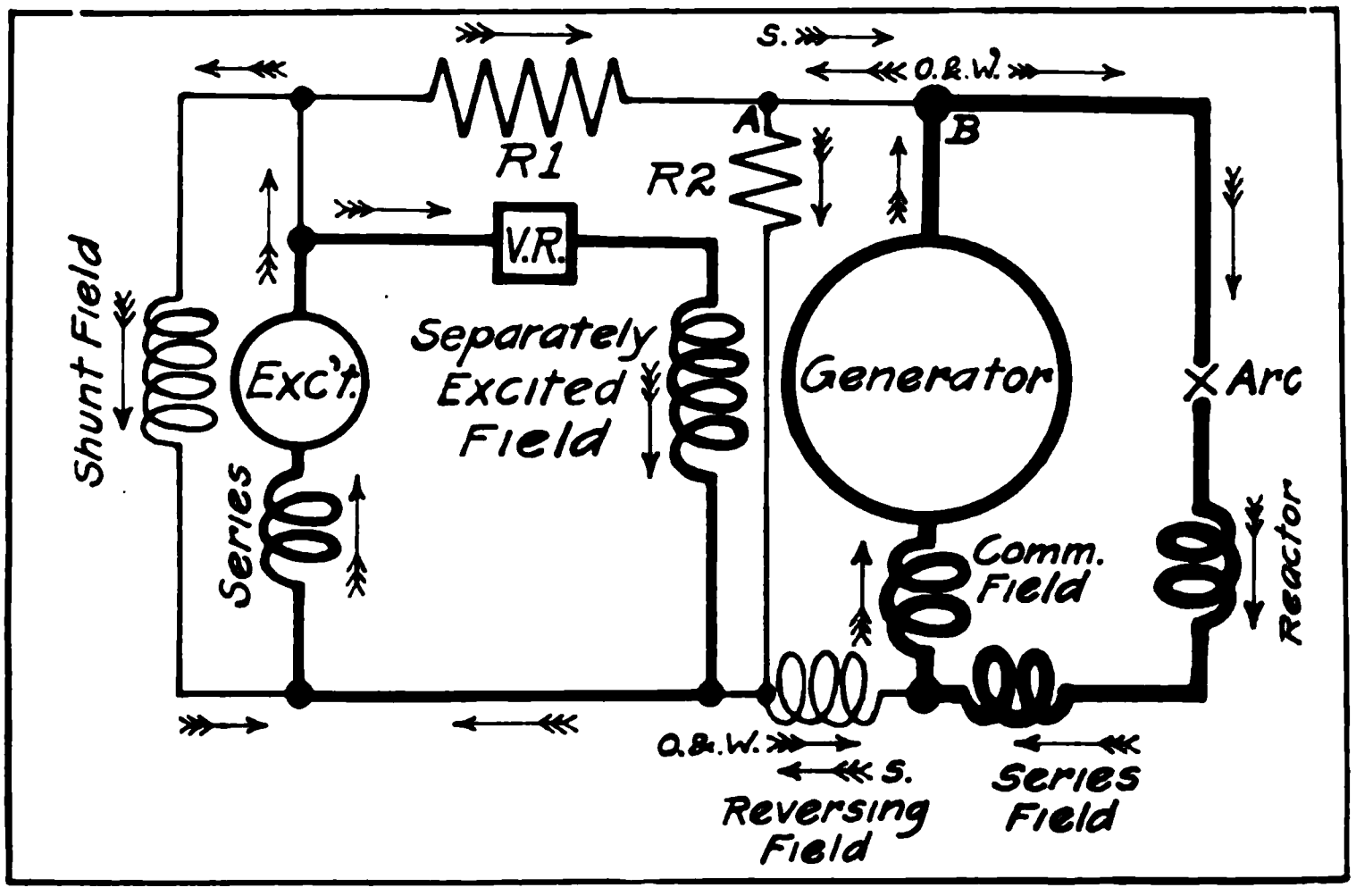

FIG. 17—WIRING DIAGRAM OF MACHINE SHOWN IN FIG. 16

the limits of 50 and 225 amperes at 20 volts for metal electrode welding and delivers 150 amperes at 35 volts for graphite electrode welding. For work requiring higher current values, two or more machines can be easily and quickly operated together in parallel by simply connecting the positive or ground cables of the various generators to the work and by connecting the negative or electrode cables to a single electrode holder. This then provides for current values as indicated by the following table:

No. of generators connected in parallel	Range of current metal electrode	Values obtainable graphite electrode
2	150-450	100-300
3	225-675	150-450
4	300-900	200-600

This type of equipment is therefore adapted to small foundries which require an appreciable amount of metallic electrode work as compared with graphite electrode work. In fact, for such foundries two medium-capacity single-operator machines, for example, will be more flexible and a better investment than a single high capacity unit because the two machines can be operated independently for two operators, whereas, only one operator can work with a high capacity single operator unit.

For building up pads on castings, especially on vertical surfaces, the metallic electrode process is the better. Many operators build up such pads somewhat over size and then trim them down with the arc using the graphite electrode. If the pad is not too large it can be brought to a temperature above a red heat so that it can be hammered vigorously, thereby improving the grain structure and external surface appearance of the deposited metal.

For filling in large cavities such as blowholes, sand holes,

FIG. 18 VOLT AMPERE CHARACTERISTICS OF MACHINE SHOWN IN FIG. 16

welding control panels are shown in Fig. 20 Typical circuit connections are illustrated by Fig 21.

In connection with this type of equipment many purchasers have failed to properly appreciate the use of a relative small reactor in each metallic electrode welding circuit in addition to the resistance to facilitate striking and holding the arc. The latter feature is most noticeable when the operator is welding on poor material containing foreign matter such as occluded gas or grease, a high percentage of carbon, or other gas-forming elements, which will have a very decided tendency to blow out the arc.

Such a reactor is illustrated by Fig. 22. This device is simply an inductive coil which delays the rate at which the current builds up through the electrode when it is touched against the work incident to striking the arc. This minimizes

FIG. 21. TYPICAL CIRCUIT CONNECTION FOR THE MACHINE SHOWN IN FIG. 19

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Discussion—Arc Welding and Cutting Practice

MR. E. WANAMAKER—Quite some time ago, some of those vitally interested in furthering electric welding, ascertained that in many instances it was highly desirable that a form of electrode be used such as would prevent some of the bad effects accruing from contact with the atmosphere of the molten and vaporous metal contained in the arc stream during the process of metallic arc welding. Quoting from an article by W. E. Ruder, research laboratory, General Electric Co., relative to effects of impurities contained in welds:

> "One of the most important factors, since the necessary property of ductility is so largely dependent upon it, is that of impurities found in the weld. All electric welds have a high oxygen content due to the highly oxidizing condition under which they are made. This oxygen content alone will not account for the lack of ductility. Microscopic examination reveals the presence in most welds of a large number of lines or plates which bear a close resemblance to those seen in iron which has been highly nitrogenized. Nitrogen does not always appear in this particular form. It also may appear as a cement between grains in such parts as contain the highest percentage of nitrogen. The needles or plates are merely one phase of the nitrogen-iron combination. In carbon steels they often do not occur at all, even when the nitrogen content is as high as 0.15 per cent. There is some indication that the nitrogen enters into combination with the iron and carbon, forming an iron-carbon-nitrogen compound. However, this has not yet been proved definitely.
>
> The needles or nitrogen lines then are merely an indication of the presence of a considerable percentage of nitrogen, but their absence does not always mean that nitrogen is not present. Strauss finds 0.12 per cent nitrogen in electric welds. Desch reports an analysis of an electric weld which contained 10 times as much nitrogen as the plate.
>
> Nitrogen is one of the most harmful elements for making steel brittle. As little as 0.06 per cent will reduce the elongation on a 0.2 per cent carbon steel from 28 per cent to 0.5 per cent. It is contained in regular steel only in small amounts, varying from 0.02 per cent in bessemer to 0.005 per cent in open-hearth steel. Under ordinary conditions of fusion, nitrogen has little effect upon iron; but under the conditions of the electric arc the nitrogen becomes much more active. This probably is due to the formation and decomposition of nitro-

gen-oxygen compounds with a consequent liberation of active atomic nitrogen. That these lines do appear in welds made in nitrogen gas alone suggests that the oxygen need not be present, the nitrogen molecule being split up by the arc stream, or perhaps the iron vapor combines directly with the nitrogen. There is some evidence that it does.

The elimination of these nitrides and oxides must be accomplished before the weld can be made ductile."'

Some recent tests performed by one of the foremost metallurgists in the country indicate that a coated type of electrode now used by the Rock Island railroad, reduces the nitrogen content in the weld to a value that is only 10 times greater than that contained in the parent metal, while in a bare wire electrode weld, the content was 40 times that of the parent metal. This would seem to justify the statement that a distinction always should be made between welds made with bare wire electrodes and those made with a coated electrode such as are now used by the Rock Island.

To those of us who for the past several years have concentrated our efforts in the electric arc welding field, probably more has been revealed than to those who have only devoted a small part of their time to the work. Especially should it be borne in mind that some of us have been in excellent position to follow up the performance of the welds in actual service, while some manufacturers who have welded the material supplied to users, have been unable to follow up the performance of their welds, and, therefore, have not had as reliable a fund of data and information with which to judge the physical properties and to aid them in deciding their future practice.

In our experience and study of many important welds, we have found that welds of major importance, welds meaning in many instances, serious loss of life and property in case of failure, are subject to failure due to fatigue and impact as well as to lack of ductility.

In view of these now-known existing facts, it is felt that we are destined to secure a metal in the weld of such quality that it will successfully withstand the fatigue imposed upon

the metal, always bearing in mind that this fatigue may be caused by impact, repeated or alternate stresses, or a combination with stresses at times highly in excess of those to which the part is ordinarily subjected.

Discussion—Arc Welding

MR. R. E. KINCAID: Mr. Candy spoke of the larger electrodes in the metal electrode process. Our experience along that line would indicate that the greatest success in the steel foundry, using electrodes of the larger size, is found when we use a high current density in the larger electrode. For instance, with a quarter inch electrode, we get the best results about 250 amperes, although we frequently run as high as 300 or 325 amperes on a quarter inch rod.

In the illustration showing the use of studs in welding grey iron, I noticed that the welding had proceeded from side to side of the joint. I believe that considerable trouble will be eliminated in this practice if the welding is done parallel to the seam. That distributes the heat along the seam so that contraction and expansion difficulties are eliminated, to a large extent.

We have found it advantageous not to bevel out the crack at all, but to drill slantwise holes, tap them out and run the studs in so that the studs enter both sides of the fracture. This method of studding adds considerable strength, due to the studding. Then the weld is put on to make the job watertight or steam-tight. I cannot endorse too strongly the statements made by Mr. Candy. If the welding industry had proceeded in the last five years on the sound and fundamental ideas to which he referred, we would be farther along than we are today.

Mr. Candy spoke about the hard line between the steel added to cast iron and the cast iron itself—that is, the hard line at the line of fusion. It seems to me that many possibilities have been opened up by the introduction of the nickel or nickel alloy electrodes for this purpose. Several jobs have been done using the steel electrodes to make the major fill, then where the job is to be machined, gouging out the line of fusion and putting a rather narrow line of this soft alloy into

the weld at that point. The net result is that the tool will cross from the cast iron into the steel without any difficulty. There also seems to be a possibility of using this alloy or pure nickel in filling the small defects in gray iron on surfaces which are to be machined. The electrode is manipulated so as to get rather shallow penetration and while we do get a hard line, using the nickel, it is so shallow that the tool crossing this hard line will not jump.

A recent application of the nickel is interesting from the steel foundryman's point of view. A steel foundryman made a casting rather high in carbon and high in manganese, but it contained a number of blow holes at the point where the machining was to be done. The ordinary mild steel electrode was used to fill in the defects, but since the casting was machined at a very high rate of speed, there was difficulty due to the hard part of the original casting adjacent to the line of fusion. It was impossible to anneal the casting; therefore we applied the nickel to the defects and were able to machine the job at the normal cutting speed without any difficulty.

Cutting Cast Iron with the Oxyacetylene Torch

By Alfred S. Kinsey, Hoboken, N. J.

The cutting of wrought iron and steel with the oxyacetylene torch has been common practice during the past 15 years, and it has generally been supposed that those metals represented the limit of the possibilities of the cutting torch. Within the past few months, however, much interest has been aroused by claims made for the cutting of cast iron with the oxyacetylene torch, notwithstanding the fact that all authorities had declared such a thing to be impossible. Of course many operators of the torch had tried in a superficial way to cut cast iron and had failed chiefly because of lack of interest.

As there are many foundrymen who have not taken the time to become familiar with the principles used when metal is cut by the oxyacetylene flame, it might be well before we proceed with our subject to consider what happens in the gas cutting of ordinary steel. In this work the torch is provided with a stream of low pressure oxygen and another of low pressure acetylene which combine to form what is known as the preheating flame. This is used to heat up the surface of the metal to be cut to a bright red, where the metal has a strong affinity for oxygen. Then an abundant supply of high pressure oxygen from a third tube of the torch is directed upon the hot surface, and cutting follows due to the rapid oxidation of the metal. This actually is burning of the pure iron, or ferrite as it is called in metallurgy. Hence the former oxyacetylene cutters are now more frequently called burners.

As the burning of the iron proceeds an ash is formed. This is known as iron oxide, and it together with any other impurities of the metal is melted and, as slag, runs out of the slot being cut, called the kerf.

There never has been any difficulty in cutting steel with the torch in this manner. Very little delay is experienced

trained cutters of the engineering service department of the above company.

The torch should be held so that the tip is tilted slightly backward for soft gray iron and more so for the harder irons as shown in Fig. 2. The cutter may easily determine the correct angle. The ignition spot on the iron must be bigger and hotter than for steel in order to insure a good start. The variableness in the hardness of the iron in most castings and also blowholes affect the cutting, sometimes "putting out the fire." A little spiral motion of the tip, however, usually will overcome the trouble. On the other hand such a motion also will widen the kerf, thereby increasing the gas consumption in burning the larger amount of metal.

The preheating flame should be adjusted with an excess of acetylene so as to give a carbonizing jet from 1 to 2 inches long when the high pressure oxygen is snapped on.

The most important part of the whole cutting operation is to maintain the proper gas pressures. These are much higher than for cutting steel as may be seen in the following table:

Cast Iron Cutting Pressures

Size of special tip	Thickness of metal inches	Oxygen pressure lbs. square inches	Acetylene pressure lbs. square inches	
No. 1	1	50	15	
No. 1	2	70	15	Regulate the pressure so as to make a carbonizing flame from 1 to 2 inches long increasing with thickness of metal.
No. 1	4	85	15	
No. 2	6	105	20	
No. 2	8	115	20	
No. 2	10	150	25	
No. 2	12	175	25	
No. 3	Over 12			

These pressures are necessarily approximate as they vary with the hardness of the casting. The operator should make certain that the oxygen supply is maintained at constant pressure. It is liable to drop due to rapid consumption, and thereby shorten the carbonizing jet and stop the cutting. The casting will not need to be preheated other than that given by the preheating flame of the cutting torch. Some of the best cutting was done out of doors at a temperature of 60

While there of course must be some decarbonizing of the surface of the casting due to the burning, there is no important increase in the hardness of the surfaces of the kerf. It is apparent that very little of the graphitic carbon changes to combined carbon, which probably is due to the protection afforded the surface by the oxide scale. It insulates the hot metal from the cold air, and allows it to cool slowly which leaves the graphitic carbon undisturbed. Suppose we try to make this a bit clearer to the beginner who has not familiarized himself with the elementary metallurgy of cast iron.

There are five standard grades of cast iron, No. 1 being the softest and No. 5 the hardest. No. 1 is of a dark gray color, No. 2 medium gray, No. 3 light gray, No. 4 mottled and No. 5 white. So we hear of gray iron, meaning Nos. 1, 2 and 3, and of white iron, referring to Nos. 4 and 5. The best castings requiring to be machined are made of gray iron, while white iron is usually used for ordinary castings not needing machining. A good average gray iron is composed of about 93 per cent pure iron (ferrite), the remainder being chemical elements in about the following proportions: Carbon, 3.50; silicon, 2.75; manganese, 0.60; phosphorus, 0.10; and sulphur, 0.05 per cent, total 7.00 per cent.

The carbon in cast iron is of two kinds, that which will not combine with ferrite called graphitic carbon and that which will combine with the ferrite and therefore known as combined carbon. The proportions of these carbons varies according to the grade of iron, the approximate amounts for an average gray iron being graphitic 3 per cent and combined 0.50 per cent. Graphitic carbon softens and combined carbon hardens cast iron. If cast iron is made red hot, as in oxyacetylene welding and cutting, and allowed to cool quickly the graphitic carbon changes to combined carbon and the metal becomes too hard to file or machine. In welding this is prevented by covering the hot casting with asbestos or fire brick. In cutting cast iron the iron oxide left on the kerf faces undoubtedly keeps the casting from cooling too rapidly and preserves its softness.

Economy of Cast Iron Cutting

The cost of cutting cast iron with the oxyacetylene torch

is about five times as much as that for cutting steel.

Steel 12 inches thick can be cut with oxygen and acetylene at the rate of about 30 square inches per minute, costing say 1.5c for labor, 10c for oxygen and 2c for acetylene, a total of 13.5c to cut 30 square inches per minute.

The 12-inch cast iron shown in the illustrations was cut at the rate of *7* square inches per minute, costing 1.5c for labor, 13c for oxygen and 4c for acetylene, a total of 18.5c to cut *7* square inches per minute.

We may therefore calculate the following approximate figures on a basis of 100 square inches of metal cut:

To Cut by Hand Torch 100 *Square Inches of Cast Iron and Steel with Oxygen and Acetylene*

	—Consumption—			——————Cost——————			
Material	Time Mins.	Oxygen cu. ft.	Acetylene cu. ft.	Time	Oxygen	Acetylene	Total
Cast iron..	15	123	21	$0.22	1.84	0.56	$2.62
Steel	3.5	25	2	0.06	0.37	0.05	0.48

While the above figures show the relative cost of cutting cast iron and steel with the oxyacetylene torch to be high for cast iron, it is fair to note that the only other way to cut cast iron, i. e., by machinery, would cost at least twice as much as cutting it with the torch. For example, the slab of cast iron shown in Fig. 5 cost $2.62 per 100 square inches to cut off with the torch, whereas to accomplish the same thing by machinery would cost at least $5.00 for labor and power if the casting were of convenient size to handle. However, the cost might be double that amount for machining a big, unwieldly casting. We may therefore summarize:

Comparative Cost of Cutting 100 *Square Inches of Metal*

Metal Cut	Method Used	Cost per 100 sq. in.
Steel.....	By Oxyacetylene Torch....	$0.48
Cast Iron.....	By Oxyacetylene Torch....	2.62
Cast Iron.....	By Machinery.....	5.00

Advantages to be Obtained from Cast Iron Cutting

While it may readily be understood that the cutting of cast iron with the oxyacetylene torch will not have as wide an application to shop practice as the cutting of steel, it surely

It is a recognized fact that the smaller the total amount of chemical elements in an iron or steel the easier the metal may be cut. This leads to the assumption that where the oxygen from the torch can unite readily with the pure iron, called ferrite, rapid oxidation or cutting will occur. This accounts for the popular use of the cutting torch on steels containing carbon up to what is called the "true steel" condition, which has a carbon content of about 0.90 per cent. There the carbon goes into complete solution with the ferrite, after which cutting is more difficult. It will be remembered that the irons contain carbon in about the following proportions:

	Per Cent Carbon
Wrought iron	0.01 to 0.10
Machinery steel	0.10 to 0.50
Tool steel	0.50 to 1.50
Malleable iron	1.50 to 2.50
Cast iron	2.50 to 4.50

The torch has been successfully used to cut metals containing as high as 0.90 per cent carbon therefore that includes wrought iron, machinery steel and tool steel.

The carbon in steel is usually in two forms called pearlite and cementite. The pearlitic carbon assists cutting, while cementitic carbon tends to interfere with it. Soft tool steel has its carbon chiefly in the pearlitic condition, but when the steel is made red hot and immersed in cold water its carbon changes to cementite and the tool becomes file hard. So we can understand why soft tool steel may readily be cut and why when it is hardened it is so difficult to oxidize it. Going on up the scale of carbon content in the last table we come finally to cast iron with its average of say 3.50 per cent carbon, in the graphitic and combined states.

Now, one may ask why cast iron could not be cut heretofore. One reason given is that the graphitic carbon distributes itself in flaky form throughout the ferrite making the whole mass infusible. Another explanation is that because of the high carbon content of cast iron the reaction between the ferrite and oxygen is slow and the stream of cold oxygen striking the hot iron tends to make the reaction still slower resulting in a loss of heat and preventing cutting. We also

have already mentioned the general belief that the iron oxide interfered.

Despite all of these obstacles cast iron is being "cut." So far as our own experiments are concerned we found that it was not necessary to heat the casting before starting to cut in order to change the nature of its carbon, as has been suggested by one writer, neither did we have to preheat the oxygen to accelerate the slow reaction between it and the ferrite due to its cooling effect. We found that while a pure reaction in cast iron cutting similar to that secured in cutting steel still seems impracticable it is possible to bring about a combined burning of the ferrite and melting of the oxide so that a comparatively satisfactory cut can be made through cast iron. All of this we believe to be due principally to two conditions: (a) The unusually large supply of oxygen and acetylene used, and (b) the additional fire created in the kerf by the excess of acetylene from the torch, the carbon from which is in finely divided particles so likely to produce a large volume of heat in the shortest time.

Conclusions

In the light of the many other fine accomplishments of the oxyacetylene torch, we are just as sanguine for this new indication of its expanding application in the world of metals, and would therefore emphasize the following:

1. That cast iron can be cut by the combined melting-oxidizing action of the oxyacetylene torch.
2. That the cutting of cast iron, even though rather roughly done, will be of advantage to shop practice in several ways, as already outlined.
3. That while the cost of cutting cast iron is high compared with the cutting of steel, that should not prevent the proper use of the new method. There will be many instances of where the torch can be successfully used on a job which could not be taken to a machine for repairs.
4. That any experienced operator of the cutting torch on steel can quickly learn to cut cast iron.
5. That a special cutting torch is unnecessary provided one is used which operates with excess of acetylene. An inexpensive tip is the only special part.

Foundry Engineering

By Frank D. Chase, Chicago.

A few years ago this country awoke to the necessity of increased efficiency in all lines of industrial and manufacturing activities, whereupon efficiency engineers sprung into being and for several years this country was inundated with them. The efficiency engineer of 10 years ago was a novel proposition and he got away with it beautifully. The average manufacturer was convinced by the technical matter appearing in the trade papers, that he was absolutely incompetent to run his plant, and he wondered how he had ever succeeded in getting along for years without the aid of an efficiency engineer. Thereupon he employed one to tell him that he knew nothing about plant operation, and to take over his plant and run it as it should be run. The efficiency engineer had a glorious career for a short time, but in the course of a few years, thousands of plants which had employed so-called efficiency engineers were able to recover from the effects of their employment and went back to manufacturing on a safe and sane basis.

Influence of Efficiency Engineers

It is needless to say that many efficiency engineers were really efficient, and effected enormous economies in plant operation, and in countless instances where the methods of the efficiency engineer were not entirely a success, their efforts to improve conditions at least succeeded in arousing the interest of the manufacturer to the possibilities of improved methods. In reality, vast good has been done to industry in this country through the activity of the efficiency engineer. Today almost every large plant has its production engineers who give scientific study to production problems, and the efficiency of production of manufacturing plants of this country has vastly increased, and we can thank the efficiency engineer, regardless of his work, for the change.

The efficiency engineer's activity was largely confined to

production, and during the past few years we have had another cycle of engineering activity, known as industrial engineering. When the writer went into business for himself 10 years ago, after having had 10 years of experience in handling industrial and railroad buildings, he recognized the necessity of scientific analysis of the problems of plant layout and design to the end that a plant would be so built that it would fit its requirements. This involves study and analysis of the manufacturing process with reference to plant layout, present and future; co-ordinating departments; anticipating expansion; introducing special equipment and labor saving mechanism; and a proper consideration of general phases, such as the proper location of a plant with reference to the supply of raw materials, supply of labor, transportation of labor, shipment and handling of raw materials and finished product, and a market for the manufactured articles. All of the problems of plant location and design require analysis with reference to efficient and economical operation, and this means with a view toward maximum profits when the books are balanced and all the factors taken into account.

The Debut of Industrial Engineer

The handling of a proposition of this sort is a real man's job, and the necessity of the proper handling of it has appealed to the manufacturers just as the efficiency engineer's plea for increased production appealed to them. The result has been that in the last three, four or five years another profession has grown up called industrial engineering. Architects who find the business dull because of building costs or war conditions, engineers whose special fields of endeavor have diminished, factory superintendents who are out of a job, machinery salesmen, and in fact almost anyone who has in any way been connected with the factory, are now terming themselves industrial engineers, and every phase of manufacturing activity is being handled by the new profession. The profession has become so big and so expert in so many lines, and has so many representatives who can do so many things, that I am of the opinion that the industrial engineer is going to follow in the footsteps of his predecessor, the efficiency engineer, and into disrepute and oblivion.

Foundry engineering threatens to go through the same cycle of need, exploitation, acceptance and discredit, because the opportunity is here now for the remodeling of many old plants, the construction of many new plants, in fact, the rejuvenation of the entire industry, and men are not slow to seize the opportunity for service in this field. The trade paper advertising again is the evidence of this fact, and we have today not only industrial engineers by the thousand, but we have foundry engineers galore.

And this is with justification, for the foundry industry needs engineering. Foundrymen the country over admit that today the foundry industry is at the threshold of a great era of development. It is quite apparent that all of the problems which we, as engineers, apply to the location, layout, design and equipment of a manufacturing plant can and must be applied to the foundry. This is a specialized phase of engineering and may very aptly be termed "foundry engineering."

The Foundry Needs Engineering

Machine shops, steel mills, and light or heavy manufacturing plants do not present the same combination of operations and characteristics. Where else is the production of an article requiring some skill dependent on the use of a shovel? Machine perfection has advanced, quantity production in the automotive industries has brought about improvements in machine design and cutting speeds, and the output per man has been enormously increased, but in the main, the increase in the foundry has fallen far behind. There has been only a part of the corresponding improvement.

In the average machining operation it is the speed of the machine which determines the operator's output. In the foundry, the number of molds a man puts up per day is more often a matter of physical fatigue and not the limitations of a particular machine, but the time requirements of all the operations until a completed mold is placed on the floor ready to pour. Every thinking foundryman is aware of the time and energy-consuming elements of making a mold; and that the best in molding machines still leaves a large part of the task up to the molder. This is but one operation in the making

of a casting, and, without dwelling on the others, is not the point well taken that foundries are not keeping pace with the strides in other industries?

Disregarding the post-war conditions, several reasons may be found for this. One is beyond question in the general inertia of the operating foundryman. Troubles are frequently difficult to explain and correct, and experiments are more often costly and not productive of definite unqualified deductions and results. Too intimate association with problems narrows vision and curbs imagination, and the average foundryman is usually too involved in maintaining his established production standards to be receptive to new ideas or to have the time in which to thoroughly analyze his possibilities.

Why Improvements Develop Slowly

Another reason more generally applies, namely, that foundry production, melting, molding, coremaking, pouring and cleaning, is so closely related to the physical limitations of a plant, that the individuals most concerned or responsible, very naturally do not conceive the possibilities of improvement which could be carried out under somewhat different conditions.

The lack of proportionate improvement alone, in foundry practices or production, ought to indicate that something is wrong and is being overlooked. Fortunately, present day conditions are necessitating in themselves some departures from established methods, directing attention and stimulating inquiry into improvements.

The small amount of study that has been given to the subject has made it clear that a properly designed foundry cannot be a conventional or standard structure with sidewalls and a roof under which equipment is placed, but essentially an equipment layout without restricting elevations and structural details, housed in such a manner as to afford an essential amount of natural light and fresh air.

Making the Foundry Attractive to Workers

The poorest unskilled laborer is receptive to agreeable working conditions. Air and light mean health. A man's attitude toward his job is in a great measure a reflection of

his physical condition and the quality and quantity of his work is fundamentally related to it. Disagreeable and unhealthful working conditions mean higher wages, dissatisfied employees, and increased labor turnovers. There is nothing new in this contention, but the foundries have been woefully backward in appreciating its significance and correcting the situation.

Conceding that competent engineers and architects can design buildings which will meet the requirements of satisfactory working conditions, this element represents only part of what is needed in the layout of a foundry designed and equipped so as to accomplish the economies which are possible, and which are being overlooked in the usual present plant construction. It is essential that every production possibility in all departments be developed to its utmost. This means an intelligent study and analysis of every production element and a comprehensive provision for the use of labor-displacing equipment which will result in a maximum output per man.

This contention may be illustrated by specific examples in every phase of foundry operation, from the receipt of raw materials to the shipping of the finished casting. In the case of the gray iron foundry, a typical example can be found in the methods with which raw materials are handled from the cars and charges from the yard to the cupolas. In general, the same methods are in vogue since the first foundry was built. Shovels and wheelbarrows have persisted, and there has been no improvement in the design of either of these two pieces of indispensably considered equipment. Pig iron and scrap is in most cases man-handled all the way from the cars to the cupolas. In many cases the small tonnages involved do not justify equipment which will effect improvements over old methods, but where the volume of material does warrant mechanical equipment, the possibilities have only been touched. On the foundry floor where any quantity of heavy flasks or castings are to be handled, a crane is immediately thought of. How much consideration has been given to the use of a crane serving a charging floor where it could be used as a charging machine and to eliminate the labor of moving loaded cars or boxes? It would give a flexibility not attainable in the usual

charging floor layout, even though it be provided with industrial tracks and ball bearing charging cars.

Handling Costs Are High

In the average foundry the handling of pig iron, scrap, coal, coke and sand from cars to yard and later to their points of consumption costs from 60 cents to $1 or more per ton, depending upon weather and the particular conditions about the plant. The sand, coke and coal are usually distributed by means of wheelbarrows negotiating a plank. Pig, piece by piece, is tossed on the ground and laboriously stacked, or use is made of a gravity conveyor or skid which still necessitates hand handling at each end.

The making up of charges and the reclaiming of coal, coke and sand from the yard to the foundry is the more expensive element of the operation. Rain, snow and ice foul the turntables, transfer cars and industrial tracks. The cars themselves are seldom kept properly lubricated and in good condition. When such a system is used, it is seldom that the track layout is sufficiently comprehensive; it only serves an area immediately adjacent to it, and necessitates the bringing, usually by hand, of all material from the piles to the cars. It has its value, but only partly meets the requirements.

Where the total quantity of raw material handled warrants the expenditure, the most economical arrangement is a travelling crane supplemented by a magnet, grab or dump bucket and most important of all, a co-ordinated bin arrangement, the details of which can be so designed as to reduce to a minimum, all handling by hand. Where a crane is not a good investment, there can be worked up combinations of relatively inexpensive stock equipment, the money-saving possibilities of which are extremely attractive.

The electric or gas tractor is a modern method of transporting practically every material in the foundry, even to hot iron. Its use is becoming more general, and some of our largest foundry layouts are developed around the tractor as the means of handling materials from one point to another throughout the entire plant.

Design of Plant Affects Costs

Lack of foresight in the beginning is responsible for the present material handling costs of many plants. The foundry has developed and tonnages have increased until the quantity of materials handled daily in the yard alone would make a heavy investment in cranes, bins and other equipment extremely profitable, but through lack of foresight, conditions have been allowed to develop which make it impractical, all things considered, to do anything but continue as in the past. The demands for expansion and improvement become so acute that not infrequently they result in a decision to abandon the plant and build anew. Such a decision is sometimes an unfortunate one, and the engineer who combines the knowledge of building design with a knowledge of foundry operations can frequently save the old plant by making changes which will serve almost as well as the erection of a new building. It is astonishing what can be accomplished in the way of remodeling an old foundry. Sometimes even new buildings have to be modified in order to accommodate increased production or secure proper working conditions. There is no greater field for the ingenuity of the engineer than in studying the possibilities of increased production and bettered conditions in the remodeling of old plants. The reader is familiar with any number of cases of this kind.

Growing Popularity of Electric Furnace

The consideration of melting equipment includes blowers, burners, furnaces and fuels. Like everything else, these are undergoing constant improvements, and some types are increasing in their range of application. Fuel costs are being readjusted. The electric furnace, primarily considered in the foundry as a steelmaker, is now being used for nonferrous metals, malleable and gray iron for high pressure, and rigid specification work. With power at 1 cent per kilowatt-hour, steel castings can be made cheaper in the electric furnace than with the converter. The determining factor is largely the price of pig and scrap. Malleable practice and air furnace melting has made little progress toward economies, with the exception of the recent success with powdered coal, which

has been long in forthcoming. Is it not surprising that the rigid requirements of malleable melting and hot metal handling have not been more generally met by the electric furnace, the more so, when it has been demonstrated that the usual 45 per cent pig charge for air furnaces can be reduced to 10 per cent in the electric furnace?

With current at 1 cent per kilowatt-hour, assuming 650 kilowatt-hours per ton, there is a direct fuel charge of $6.50 per ton of metal melted. With a 2 to 1 air furnace melting ratio and a cost of coal into the furnace of $7.50, there is a difference of $2.75 per ton on fuel in favor of the air furnace. However, a 45 per cent pig charge at $45 per ton can be replaced by 10 per cent pig and 35 per cent of scrap at $30 per ton. The fuel saving of $2.75 for the air furnace is offset by a saving of $4.75 in the cost of the charge for the electric furnace, or, for these two items there is a net difference of $2 per ton of melt in favor of the electric furnace. For a strict comparison of the two methods, all the items must be taken into account, but the foregoing and most important are given to indicate that electric furnace malleable has economical possibilities which have not been generally appreciated. Consider further with the electric furnace the possibilities of using cupola metal in reducing the fuel or energy cost, together with the higher temperatures and more uniform analysis obtainable with it. There are districts where conditions now are such that the costs for electric malleable would compare favorably with the air furnace for malleable, this comparison disregarding the possible savings of a duplex or triplex process which may possibly be developed to show still lower costs for the electric furnace. Some recent successes of powdered coal for malleable melting are showing substantial savings over hand firing, and it is an interesting fact that in most cases where the performance has been satisfactory, the results have been due largely to the efforts of ex-foundrymen, or malleable men who have become interested in the subject.

It is not in the scope of this paper to discuss in detail any of these subjects, but is not the point apparent that here again is an instance where the intelligent handling of the problem is

beyond the capabilities of a pure foundryman or a combustion engineer? Beyond question the work is best covered by the term "foundry engineering."

Cutting Down Molding Costs

The heart of production lies in molding. Here if anywhere in the foundry, we should expect to find a proper degree of progress over the methods in use 15 years ago. But this is true only to a limited extent in the foundries making automobile castings or other specialties in quantities. In general, it is only the heavier tonnages in specialties which make possible and economical the installations of sand handling and mold conveying equipment on a large scale, but there are feasible a number of other combinations of less expensive equipment which can be used to reduce the labor of shoveling and cutting sand and handling flasks to, and molds from, machines. It goes without saying that the last mentioned elements do not apply to snap or other small flask work, but any foundryman will admit that in general the usual main crane equipment is not sufficient to enable the molders to work without tie-ups waiting for lifts and to close.

The complaint of every foundryman nowadays is that good mechanics, all-around molders, etc., are not to be had, and yet an attempt is made to obtain production according to the old methods. Molding is ceasing to be a highly skilled trade. The average shop does not have a number of all-around molders who can be depended upon to turn out a good casting from any pattern given them. The time was when a shoemaker or a cabinet maker made a finished article from his raw materials, but modern production has no place for such methods. Wherever possible, each man now performs his own particular operation. The analogy is admittedly not rigid for the molder and foundry, but it is proper to question some current foundry practices in the light or what is being done in other manufacturing lines.

Increasing Capacity of Molding Floors

Bear in mind that in making a casting there is the preparation of a drag, a cope, finishing, setting of cores, closing and pouring and sometimes the molder assists in shaking out and

cuts part of his own sand. In most cases, particularly for gray iron and malleable, all molding ceases when the first iron comes off, and the molders use an amount of productive time which might be cut in one-third if all could be kept busy at the operation, or if a separate crew performed the task. Closing up is often delayed waiting for the crane, and the usual hunt at the expense of molders' time, takes place for clamps and wedges. And it is the molders who are scarce and whose daily output largely determine production! The inference is obvious, but it must not be inferred that it is claimed that a splitting up of operations is applicable to all classes of work and conditions. There are, however, any number of instances where improvements in this direction can be made. Some of them when tonnages are sufficient, necessitate or make possible continuous pouring. This operation requires careful analysis of methods of mechanical handling.

Here again the opportunities for the utilization of old plants is practically unlimited. We recently estimated that in a gray iron foundry in New York state, now running on a basis of pouring once a day, a change to continuous pouring is entirely feasible owing to the uniformity of the work, and that by the installation of the continuous pouring operation with practically no increased costs of equipment, building area or capacity, an increased profit of approximately $200,000 per year could be earned. The total expense to obtain this was perhaps $25,000. Further comment is unnecessary.

Where the several operations may be split up, frequently the pouring itself may be divorced from the molder, but there must be worked out a plan whereby the responsibility for scrap is fixed, particularly when the shop is being run on a piece-work basis. Continuous pouring to be carried out most advantageously precludes the facilities for the removal of hot castings, and it necessitates a type of building construction which will adequately remove the resulting smoke and fumes and maintain a sufficiently cool, working temperature. Monitor, sawtooth, A-frame, or a Pond truss type of roof construction can not accomplish the desired results unless designed in accordance with heat producing zones, with proper appreciation

of the conditions which will exist at all points in the building. Hot, gas-laden air cannot be removed from a structure unless cool air can be admitted in its place. Forced ventilation is to natural ventilation as artificial light is to sunlight. It is more expensive and a poor substitute; so again in the foundry proper, or molding area, we have a large production problem involving the immediate installation of a variety of mechanical equipment, or provision for it in the future, and the whole housed in such a manner as to provide a maximum of daylight and fresh air. Cannot the problem best be handled by an organization in which has been brought together foundrymen, architectural, structural and mechanical engineers, whose services may rightly be called "foundry engineering"?

Conserving Labor in Cleaning Room

The cleaning room of most plants is another indication of the extent to which old methods have persisted. The time required for a batch of castings in a tumbling barrel is half consumed by the loading and unloading operations. Castings, piece by piece, or by means of a shovel for the smaller ones, are laboriously raised from the floors and deposited into the mills, and the unloading operation shows a small improvement. There are obvious economies possible in many cases with barrels which are elevated and served by a platform at mill height, from which a mill may be quickly loaded and emptied frequently direct into the boxes under the mill, without additional handling of each piece or the use of a shovel. But as in the other cases, the usual building elevations, allowable truss loads, etc., do not permit of such arrangements because the structure was not designed primarily to fit the operations.

There is some argument about the relative merits of one and two story foundries. This is a matter which is not particularly difficult to determine, because each case must be handled on its merits and what fits one plant will not fit another. There are too many factors which vary.

Consider Welfare of Men

The proper type of building not only guarantees good light and ventilation where the wrong type makes the building

a difficult one to hold good men, but many other items of men's welfare must be considered. There are few industries which offer more unattractive surroundings to labor than the foundry plant. This does not mean unhealthy surroundings, because foundry work is extremely healthy with the exception of inhuman sandblast rooms which still exist in some instances. The time has come, whether we are willing to admit it or not, that decent accommodations must be provided for working men. There is much argument as to whether or not improved conditions are appreciated, whether they pay and all that sort of thing, but the fact remains that men are entitled to better conditions than most of them get today, and that they are going to have them. In my opinion it is better to give it to them and educate them to appreciate better conditions, thereby making them better men and citizens. This matter of employes' welfare is a life study in itself. The providing of proper wash rooms, locker rooms, toilet rooms, rest and eating rooms are all a part of the engineer's job.

Time permits the mentioning of but a few of the instances wherein details of foundry construction and methods are not what they should be. This is again unfortunate, because in a few words it is not possible to discuss specifically the conditions to which some of the criticisms apply, and the statements may seem to be too broad and sweeping, and operating men will take issue with them.

Need All-Around Experience

It is becoming more and more evident to those who are in constant contact with problems of economical foundry layout, that intelligent handling of the subject calls for a combination of experience and intimate knowledge of foundry practices, together with structural and architectural design, which is beyond the province of one man, but can only be provided by a combination of men or an organization which has been built up to meet these specialized requirements.

The underlying requirement, however, in detail, design and location is a first hand knowledge from the foundry standpoint of the conditions involved; a broad familiarity with equipment, characteristics and possibilities; and the two

co-ordinated in an engineering organization, which, functioning as a whole, can make the most of the opportunities. The individual efforts of a contractor, an architect and a foundryman, joined for a short time only, can rarely produce a foundry of economical design and good operating efficiency.

The subject has been touched upon broadly and it is assumed that the contentions will be so interpreted. What is held to be impossible today will be accomplished tomorrow. Many of these accomplishments are past due, and the next few years will witness some marked improvements in foundry design, methods and operation, and foundry engineers will have had no small part in bringing them about.

Important Considerations in the Design of Modern Foundries

By J. H. Hopp, Chicago

In designing a modern foundry the engineer must take into consideration, first of all, the practical operation of the plant when completed. Following this, a careful study must be made of the kind and size of castings required, as well as the quantity desired. This applies particularly to quantity production. It is equally as important that a shop to produce jobbing castings be given careful study of the work contemplated.

The building which is to house these operations can be constructed in various ways and of many kinds of materials, but it should be made with only two thoughts in mind, namely, that of co-ordinating with the plan of operation and acting as a protection against the elements. Unfortunately, the general plan of procedure is to erect the structure and afterward try to find an ideal plan of operation to suit the building.

Good Lighting is Essential

In addition to fulfilling the conditions outlined, the building must afford all the light possible so that molding operations can be carried on without artificial light. There are no buildings in general manufacturing that require as efficient ventilation as is necessary in foundries, particularly because of the gases, steam and dirt ever prevalent.

The most suitable foundry site usually involves no other consideration than that it be adjacent to railroad facilities, and even this often is not considered. The site should not only permit of future growth but should be correctly situated with relation to the balance of plant. Another item which cannot be disregarded is the disposal of the waste products. If the property is suitable for filling at certain portions it is more desirable than entirely level ground.

A few foundries conducted along radically different lines—some poorly equipped and others over-equipped; some without

system at all and many over-burdened with system—have, by their financial successes, exploded any thought as to the necessity for careful study or scientific operation. On the contrary, without stating the various and obvious reasons therefor, every practical foundryman of broad experience with finance must have concluded long before this that no business, especially a foundry, can afford to operate along doubtful lines.

Sand Should be Carefully Stored

The majority of foundrymen know that while "pigs is pigs" all pig iron is not alike. This is true of the other materials. Apparently as negligible a thing as sand (and it is spoken of lightly on account of its comparatively low cost) can so greatly reduce a given day's profits as to more than make worth while the separate storage of each car of sand purchased. At times, and under certain conditions, it would not only be unnecessary but unwise to separate certain sands, depending upon their use in the foundry or core room. From the foregoing general statement only one conclusion can be drawn, namely, that the proper and separate storage of raw materials is not only essential but vital to success.

The material storage yard considered ideal by builders of foundries is one wherein the yard area is served by a crane with a magnet and clam shell bucket. This equipment is a valuable adjunct—but its installation, without thought as to breakdown or without thought as to the kind of cars in which the raw material is received, or the nature of the material to be handled, is one of the most common mistakes made.

Many foundrymen consider the ideal condition one in which the yard is served by a crane delivering the raw materials to the charging floor, generally by magnet. It can be proved quite clearly that in many cases this is not the most satisfactory. The writer is aware that exception will be taken to this statement by many and justifiably so, but principally for the reason that they have not studied the operations incident to the making up of their charges carefully. Many foundrymen do not believe it is necessary that the materials be weighed separately or as a whole.

Foundrymen are prone to throw up both hands in utter horror of the thought of heating the buildings in which the sand is stored. The word "buildings" is used advisedly. If those to whom this method does not appeal could record the amount of scrap produced as a result of frozen or too wet sand they would agree that heated buildings for sand storage is a profitable investment. It is advisable that not only the sand be stored in suitable buildings but that the coke also be protected from the elements.

Those familiar with the practical operation of foundries realize that work in the open in all sorts of weather, perhaps digging pig iron out with a pick, is not a pleasant task and it is for this reason that the storage yard completely covered, and in some cases entirely enclosed, is not only preferable to any other system, but on account of the better working conditions should be the cause of less dissatisfaction.

The charging floor area in many foundries is too small; provision should be made in arranging the area so that a surplus supply of material can be maintained on the charging floor to be used in emergencies. Even so simple a detail as the floor itself is neglected.

Keep Machinery Free From Dirt

Blowers and compressors, together with driving equipment, are generally placed in the area left after equipment of lesser importance has been located. Cleanliness in this direction and the possible damage from water seem to receive only passing thought. All of this has resulted in the almost universal condemnation of belt-driven equipment. Even the absolute necessity of supplying blowers and compressors with clean, cool air is considered by many as "getting things down too fine." This is also the general comment when suitable provision is made for washing the windows, particularly those in the generally inaccessible places. The windows are valuable directly in proportion to their ability to transmit light.

The recommendation that an elevator shaft be entirely closed generally does not meet with hearty approval, but when one considers the amount of grit and dirt arising in this shaft

and that the greased guides will hold this grit, ultimately shortening the life of the parts applied, no further argument irrespective of the requirements of the law, should be necessary.

The erection of a foundry on a certain sized piece of property which will not permit of the most ideal conditions with regard to the size of the floors, and which will not permit the building being set far enough away from all surrounding buildings so as not to obstruct ventilation and light, is a mistake that forever precludes the possibility of maximum production.

The Heating Problem

It is not possible to enter into a discussion of the respective merits of various types of buildings from the standpoint of their original cost, upkeep, or ability to resist fire. It is, however, fitting to say that natural light can hardly be furnished in too large quantities. This also applies to ventilation. The matter of heating, however, carries with it a somewhat different angle. The foundry must be heated sufficiently at all times to prevent the freezing of the sand. This is possible in varying degrees by means of any of the systems in vogue. Certain systems, however, are able in the summer months to bring some relief from the abnormal heat conditions existing and in addition even during the winter period are able to bring about a change of air mechanically and in this manner make the foundry a more desirable place in which to work.

On account of the general necessity of night work as well as molding on dark days, the problem of lighting a foundry is such that a study should be made of just what is required and of the areas that should be lighted best. It is false economy to run a few general conduits and drop a few carbon lamps from the ceiling. These statements with reference to the general procedure are by no means isolated cases, as the writer's opportunity to observe these points in hundreds of foundries proves that the majority of foundries pay little attention to such details.

The proper system of delivering water to the floors and air lines for supplying the molding machines is generally an after-thought rather than a part of the unit intended to be complete. It is in this and similar problems that an engineer

conversant with the practical requirements of the foundry can furnish his clients piping systems that will not necessitate tearing out hundreds of dollars worth of work to make a few additional connections.

Labor Saving Equipment

With the growing tendency for young men not to enter this industry, particularly as apprentices at a low rate of wages, the necessity of mechanical equipment without overburdening oneself with this sort of thing can be said to be absolutely necessary to success. The limit in labor saving equipment in the foundry has by no means been reached, but considerable progress has been made and more progress will be made when a readjustment of selling prices becomes necessary.

The cutting of the sand heap by mechanical means, conserving for the molder that energy so necessary to production, has been a big step in assisting the molder. To accomplish this end the arrangement of the floors and the floor construction need to be taken into consideration if this work is to be done at a minimum cost.

To the writer's mind the core room presents in the majority of plants, an equivalent to the rest of the industry, comparable with the drafting room or engineering department of a manufacturing plant. Let there be the slightest opportunity for misconstruction of a figure, an arrow head or a line, and the machine shop, pattern shop and the foundry are ever ready with the timeworn alibi, "Well, it's up to the engineering department," or, "it's up to the core room." Often this charge is just.

In modern production the core room is a much more vital factor than ever before. Not many years ago a foundryman would look at the patterns of a prospective customer, view with dismay the cores as indicated by the prints, and say, "We don't want the job; we're running a foundry, not a core room." Today we are of one opinion generally, and that is that the difficult parts of the mold can best be made with cores. For this reason, coupled with the fact that skilled men or molders are becoming less plentiful each year, it is necessary that the core room be given considerable thought, not only as to size

but the equipment and routine of the work as it progresses through the various stages until the assembled core is ready to be placed in the mold.

With the cores becoming a large factor in production as compared with the quantity of sand used, it has been found advisable and economical to reclaim this sand, not alone for its sand value but for such portion of the bonding elements as may remain. Many foundrymen are still satisfied if they are able to secure a bake of cores over night from a given oven. It is common practice to see ovens occupying no greater amount of floor area producing several bakes a day, depending upon the nature of the cores.

Generally speaking, a suitable shakeout area has not been considered necessary and it is common to find in foundries today, heaps of core sand, broken cores, rods, anchors, etc., piled mountain high under the crane, in an area valuable as molding space, with little or no arrangement whatsoever for the convenient removal of this refuse. The problem of arranging for this is not a difficult one, but a neglected one.

Sand Blast Equipment Has Improved

Not many years have elapsed since purchasers were content to receive castings which had been wire-brushed and chipped. Today there is a growing demand, at least in certain classes of castings, that they be sand blasted. The crude methods of doing this work a few years ago under conditions that were anything but livable have been discarded. Now the operator is almost entirely free from the dust.

The location of such equipment must be determined in advance, as suitable pits and foundations are required and the equipment cannot be moved conveniently at will. Frequently the sand blast table, room or barrel, as the case may be, is located in some far away corner without thought as to what must be done with the castings after they are brought from the sand blast room.

There can be no question that all castings do not require to be sand blasted; therefore, the mill equipment of a cleaning room needs consideration. The progress of the castings from the foundry to shakeout in the larger work and thence to the

cleaning room and to the various pieces of equipment therein can be readily predetermined, and the equipment for handling the castings so arranged as to assist in the loading and the unloading of the mills for the heavier work.

Every foundry should have suitable pattern storage facilities as well as patternmaking and flask repairing departments. As the patterns in any foundry are valuable assets they should be protected from the possibility of destruction by fire. It is obvious that a building used for this purpose should be made as nearly fireproof as possible and should be separated from other buildings.

It seems unnecessary to state that patterns should be filed in a systematic manner with suitable records kept covering each one. All shelves must be flexible to permit the reception of patterns of various sizes. The method so commonly in use of having some one man around the plant who knows every pattern and when asked, "Can you locate it?" casts longing glances toward the heavens and answers, "I'll look for it," is surely not a satisfactory method for this day and age.

Pattern shops or patternmaking departments usually need the same sort of thought with reference to the layout, general placing of equipment, storage of lumber, etc., as would be incidental to the machine shop contemplating certain manufacturing processes. The proper arrangement of the equipment with reference to sequence of operations and arrangement of line shafting, shaving ducts, etc., is essential.

It is impossible in so brief a paper to discuss in detail every phase of so complex a problem, but it is not out of place to state that there is not one of us, who, if he will but reflect occasionally, will find in his own plant an opportunity to improve results and relieve the amount of labor required. If this association could secure from the manufacturers of this country a statement from time to time, as to short-cut methods and their application and the results following, it would form as a basis for the future, data of inestimable value to the industry. In the absence of such data we are compelled to continue to design foundries which do not measure up to perfection.

Concrete Foundry Floors

By H. C. Boyden, Chicago

At the Philadelphia convention last fall Hutton H. Haley presented an able paper on the subject "Concrete Foundry Floors," and it is the purpose of this paper not to duplicate Mr. Haley's work, but to present certain recent developments in the art of making concrete which were not then available, and to emphasize certain features of concrete foundry floor design and construction.

The first question asked by a foundryman on this subject is "What are the advantages to be derived from a concrete floor in a foundry?" Those advantages can be summarized as follows:

Advantages of Concrete Floors

First.—The output and efficiency of the molders is increased because of better working conditions, ease of shoveling molding sand, and the incentive to keep the shop in an orderly condition.

Second.—The cost of production is decreased because of the case of moving flasks, sand and finished products by hand or motor trucks on cement floors.

Third.—Molding sand does not get mixed with floor dirt and thus become wasted.

Fourth.—Holes are not accidentally formed in the floor.

Fifth.—Small castings, tools, bolts, etc., do not get embedded in the floor and lost.

Sixth.—There is a smooth, level, unyielding surface always ready for the placing of flasks and molds.

In view of these advantages, some of which were mentioned by Mr. Haley, why have not concrete foundry floors been used more frequently? The reason is that because of lack of proper information certain fancied objections have been raised, namely that concrete floors break up under rough usage, that the surface spalls when molten metal is spilled, that the spilled metal "pops" with resulting danger to workmen, and that the advantages do not warrant the cost.

Laboratory Investigations

In the past there has been some ground for these objections because of the poor results sometimes obtained when the floors were built without a proper knowledge of how they should be designed and laid. Today, however, full information is available on the subject of concrete floors, and if proper construction methods are used the above objections are groundless. For the last five years exhaustive studies have been carried on at the structural materials research laboratory at Lewis institute, Chicago, under the direction of Prof. Duff A. Abrams, to discover the basic facts and principles that govern the making of concrete, and the best ways to apply those facts and principles so as to secure the best results.

A large part of the conclusions of those investigations apply to concrete foundry floors and if the simple rules laid down by Prof. Abrams are carefully followed, vastly better concrete floors will be secured.

A concrete floor should be just as carefully designed and as much care should be taken in its construction as in the design and erection of the building over it. The floor is the part of the building which receives the hardest use and wear, and therefore proper thought and care should be used in its construction. Perhaps the best way to emphasize the proper methods of constructing concrete foundry floors is to take up the objections that are sometimes made and show how the methods developed by Prof. Abrams' studies will eliminate them.

The danger that the floor will break under the rough usage occasioned by the handling of heavy castings can be prevented by making it of a proper thickness and of a concrete of high compressive and wear-resisting strength. In general the floor should not be less than 5 inches thick, and in foundries making heavy castings the thickness should be 7 inches.

Aggregate Should Be Analyzed

The studies at the laboratory have proved that concrete with a compressive strength of 3000 to 5000 pounds per square inch can readily be made if a few simple but important rules are followed. The first is that an analysis should be made of the aggregate—sand and pebbles or broken stone—that is to be

used, and the proportions that will give the greatest strength be determined and adopted. There is only one such proportion for each aggregate and it can readily be found. "Abrams' Table of Proportions and Quantities" has recently been published and gives full information on this point.

The second rule is to use just as little water in mixing the concrete as possible, and at the same time have a workable, plastic mixture. The laboratory investigations have shown that up to a certain point the compressive strength of concrete increases as the water ratio decreases, and that the limiting water ratio is considerably below the ratio required to give a workable, plastic mixture. The water ratio is always figured as gallons of water to one sack of cement.

The proper water ratio varies for different aggregates and mixtures so that it must be determined for each case. To determine it a simple test, called the "slump test," has been devised. A frustrum of a cone 4 inches in diameter at the top, 8 inches in diameter at the bottom and 12 inches high, made of sheet metal, is filled with the concrete to be tested, which is placed in the casing in layers, and carefully worked with an iron rod while being placed. The casing is immediately lifted off and the settlement or "slump" is measured. For a foundry floor the proper slump is between 1 inch and 1½ inches. A greater slump indicates the use of too much water.

Determining Amount of Water

As a guide in determining the proper amounts of water to be used the following approximation may be useful. With a 1-2-4 mixture use 6 to 6½ gallons of water for each sack of cement; for a 1-2-3 mixture use 5¾ to 6¼ gallons; and for a 1-1½-3 mixture, use 5½ to 6 gallons.

The third rule is to mix the concrete thoroughly; if a mechanical mixer is used, it should be turned at least one minute after all the ingredients, including the water, have been placed in the drum. If the concrete is mixed by hand, it should be turned at least five times on the mixing platform. Machine mixing is advisable because of the uniformity of the product thus secured.

For a foundry, a concrete floor should be built in one course and should either be continuous or in sections without expansion joints, except that if desired, joints may be made next to the building walls. If the building is divided into bays by columns, each section may cover an entire bay; the floor can be laid in alternate bays and the omitted bays filled in after the first ones have hardened.

Floor Should Be Rolled

The floor should not be troweled with a steel trowel, but should be rolled with a steel roller 8 or 10 inches in diameter, about 6 feet long, and weighing about 100 pounds. This rolling will add greatly to the strength of the floor by squeezing out any excess water, thereby reducing the water ratio.

The final step in the construction of a concrete floor is one of the most important, and yet is only too often neglected, greatly to the detriment of the floor. That final step is suitable protection for the floor during its early hardening period, which, as brought out by laboratory investigations, greatly influences the compressive strength and resistance to wear of concrete.

How to Increase Strength of Floor

In order to attain its maximum strength and hardness a concrete floor must be kept warm and damp during this period. Covering a concrete floor with damp sand, as soon as it has hardened sufficiently, and keeping it damp by frequent sprinkling for the first 21 days, will increase its compressive strength over 75 per cent and its resistance to wear over 40 per cent. In other words this one precaution will give the owner of a concrete floor over 40 per cent greater value for his money. Still better results will be secured if this protection can be continued for three weeks. This protection is standard practice in the construction of concrete roads, where small dikes are often built, and the surface kept flooded with a few inches of water for two or three weeks. Similar protection should be given to concrete floors. Carrying the same idea a step further, it is best not to use the floor until four weeks after it is laid.

If these few rules are carefully observed in the construction of a concrete foundry floor, it will successfully withstand hard usage.

Judging from the evidence of men who have used concrete floors in foundries for years, and from the writer's personal observations, the question of whether the surface of the floor will spall when molten metal is spilled upon it, is not serious. It would be well, however, to avoid the use of granite or quartz gravel aggregates in the construction of such floors, because those materials do not stand heat as well as certain other aggregates. Trap rock possibly makes the best aggregate for resisting heat, and slag, limestone, or limestone gravel may be used with excellent results.

Moisture Only Cause of Spalling

Recently the writer examined a large concrete foundry floor and found only one small place where the surface had spalled from spilt metal. This spot was only an eighth of an inch in depth and an examination showed that the surface had either been put on as a finishing coat or too much mortar had been brought to the surface by troweling. The superintendent of this foundry stated that he had used a concrete floor for over eight years, that it was in excellent condition at the end of that time, and that he considered it to be the best type of floor for a foundry.

Hot metal where spilled on a concrete floor will not pop unless the floor is wet or the concrete contains moisture. A concrete floor can become moist in only two ways: First from water spilled on the surface, and second by absorbing water from the ground beneath. The spilling of water on the floor surface is under the control of the shop foreman and of the molders themselves, and the results, viz., the popping of spilled metal, will be the same no matter what type of floor is used. The second cause of moisture in a concrete floor, absorption from the sub-base, can be avoided by properly draining the sub-base and spreading a few inches of porous gravel, cinders or other suitable material over the ground before laying the floor. Furthermore, if the concrete is properly made, it will be watertight and will not absorb water in this manner.

At the convention of this association a year ago, Mr. Haley in the above mentioned paper, presented another method of preventing this trouble. He advocates rolling the surface of the fresh concrete with a roller having parallel or checkered corrugations ⅜-inch deep, the roller to be of sufficient weight to make full indentations in the concrete surface. The theory is that the sand which will remain in these depressions, even though the floor is swept, will prevent the popping of molten metal.

Increased Output on Concrete Floor

In conclusion, to summarize the advantages of concrete foundry floors, consider the following illustration. Two foundry foremen, both molders, had been working in a foundry with a clay floor and were moved into one with a concrete floor. One of them had been turning out 23 molds a day of a certain pattern. Three days after moving onto a concrete floor he increased his daily output to 28, and maintained it at that point. Similarly, the other man increased his production by six or eight molds a day. In both cases exactly the same pattern was used and the added molds were made without additional effort on their part and much to their surprise. In other words, the concrete floor increased the production of these men over 22 per cent.

Discussion—Concrete Molding Forms

MR. B. C. PAGE—Is there any advantage to be gained by mixing a certain amount of iron borings with the top layer of the floor?

MR. H. C. BOYDEN—That mixture has been used and with very good success in some cases. The Portland Cement association does not recommend the use of any material in the floors, except the proper ingredients for the making of good concrete. In other words, we feel that with the proper proportions, the proper methods of mixing and dressing, and especially the proper curing methods are followed as good results will be obtained as have been obtained with the use of iron borings or other floor hardenings.

A MEMBER—In testing concrete is the cone filled with cement and pounded down with the rod?

MR. H. C. BOYDEN—It is worked with a rod. The concrete as it comes from the mixer should be put in the cone, each layer being rodded about 20 or 25 times with a pointed metal rod about ⅝ inch in diameter. Do not use a square cut rod. Put in three layers and work each layer until level with the top. Then lift off the cone and measure the slump of the pile of concrete. The settlement will take place in less than a minute after the cone has been removed.

MR. H. R. EVANS—Is it advisable to use iron borings?

MR. H. C. BOYDEN—I don't see any reason why proper concrete cannot be put in just exactly the same as you can get anything else done properly if you will give it proper supervision. There is no need to put in any other ingredient in concrete to obtain good service if you will give it proper supervision. I realize that oftentimes poor construction is carried on because of the lack of proper supervision. If the rules are followed and the supervision is good you will get the desired result.

Report of A. F. A. Committee on Foundry Scrap

TENTATIVE SPECIFICATIONS OF CAST IRON MALLEABLE AND STEEL SCRAP

Cast Scrap

No. 1 Machine Scrap: This material shall consist of cast iron scrap of first quality which possesses evidences of having been machined, except car wheels, such as planed or turned surfaces, bored or drilled holes, etc. It must be cupola size, no piece to weigh more than 100 pounds and must not exceed 24 inches in length or width. Scrap not meeting the above specifications shall not be accepted.

No. 2 Machinery Scrap: This material shall consist of cast iron scrap of first quality which possesses evidences of having been machined, except car wheels, such as planed or turned surfaces, bored or drilled holes, etc., which weighs more than 100 pounds and can be broken by ordinary drop methods into cupola size.

No. 3 Common Scrap: This material shall consist of cast scrap such as columns, pipes, plates and rough castings of miscellaneous nature broken to cupola size, pieces not to exceed 100 pounds in weight and must not exceed 24 inches in length or width, and to be free from an excessive amount of any foreign material.

No. 4 Common Scrap: This material shall consist of column, pipes, plates and rough castings of miscellaneous nature which weigh more than 100 pounds and can be broken by ordinary drop methods into cupola size.

Burnt Cast Scrap: This material shall consist of grate bars, stove plates, hardening boxes and any miscellaneous burnt scrap.

No. 1 Stove Plate Scrap: This material shall consist of the best class of clean stove plates. Must be free from malle-

able and steel parts, grates, burnt iron and other miscellaneous scrap usually collected with this material.

No. 1 Agricultural Scrap: This material shall consist of cast iron parts of agricultural machinery and shall be free from steel, malleable, chilled iron such as plowpoints, etc.

No. 1 Railroad Scrap: This material shall consist only of chilled cast iron car wheels conforming to the Master Car Builders' Association standards.

No. 2 Railroad Scrap: This material shall consist of miscellaneous railroad cast scrap to be free from brake shoes.

No. 3 Railroad Scrap: This material shall be known as Brake Shoes and shall include all types of shoes manufactured.

No. 1 Radiator Scrap: This material shall consist of radiator castings broken with all steel, malleable and other parts removed. Must be free from excessive scale, rust and corrosion.

No. 2 Radiator Scrap: This material shall consist of radiator castings not broken with all steel, malleable and other parts removed. It must be free from all scale, rust and corrosion.

Malleable Scrap: Only such scrap as has undergone the annealing process shall be in the following specifications:

Heavy Malleable Scrap: This material shall consist of malleable parts of automobiles, railroad cars and miscellaneous heavy malleable castings, and must be free from steel forgings, stampings and gray iron parts.

Light Malleable Scrap: This material shall consist of malleable parts of agricultural implements, malleable stove plates, etc., and must be free from steel and wrought iron.

OPEN-HEARTH STEEL SCRAP

Heavy Open-Hearth Scrap

No. 1—Heavy Structural Steel Scrap: This material shall consist of all structural shapes, such as channels, angles, I-beams, plates, fabricated sections, etc., 1/4-inch in section and heavier. It must be of charging-box size not to exceed

5 feet long and 18 inches wide. No piece shall weigh less than 10 pounds nor more than 600 pounds.

This material must be free from bent and twisted pieces and iron of every description. It must not include any material that is covered with excessive rust or corrosion.

The following material will not be acceptable under this classification: narrow or spear shaped plate, steel trimmings, or boiler plate having stay bolts attached.

No. 2—Miscellaneous Steel Rails: This material shall consist of standard sections of all weights, and frogs, switches, guard rails and crossing rails cut apart. It must not include any pieces that are covered with excessive rust or corrosion.

(a) Reinforcing bars need not be cut apart if so sold by the railroads under the scrap classification of the Railway Storekeepers' Association.

(b) Girder rails not to have more than 10 per cent of the weight represented in cast welds.

(c) If divisional classification for rails according to weight is desirable it should be on the basis of standard sections over and under 50 pounds per yard.

(d) If ordered to be cut to charging-box size the length shall not exceed 5 feet.

(e) If frogs, guard rails, switches and crossing rails are not to be cut apart but are to be of charging box size, the length shall not be over 5 feet and width not over 18 inches.

No. 3—Heavy Cast Steel Scrap: This material shall consist of mild steel castings of a miscellaneous character. No piece shall weigh more than 300 pounds or less than 10 pounds. It must not contain malleable or cast iron and must be free from excessive rust or corrosion. It must not exceed charging-box size, 5 feet long and 18 inches wide.

No. 4—Springs: This material shall consist of steel springs including all steel railroad coil and elliptical springs. No bar or coil springs under 3/8-inch in thickness or diameter will be accepted. The springs shall be free from plates. Elliptical springs must be cut apart and material must be free from excessive rust or corrosion.

No. 5—Light Steel Scrap: This material shall consist of

turnings, drillings and borings from wrought iron and steel both mild and high carbon. It must be clean and free from cast iron and malleable borings, brass, alloy steel and other metals. The material also must be clean and free from dirt and lumps as well as from excessive rust and corrosion.

No. 6—Bundled Scrap: This material shall consist of bundled scrap and all light steel scrap under 1/4-inch in section, free from tinned and galvanized material. Must not be larger than a cube of 24 inches dimension. Must also be free from excessive rust and corrosion.

CONVERTER STEEL SCRAP

No. 1: This material shall consist of mild open-hearth steel scrap such as structural shapes, rolling mill crop ends, forgings and forge crop ends. No piece shall weigh more than 200 pounds nor less than 10 pounds and must not exceed 24 inches in length or width. Material must be free from excessive rust or corrosion.

No. 2: This material shall consist of open-hearth steel scrap, such as rails and high carbon or hard steel scrap of a miscellaneous character. No piece shall weigh less than 25 pounds or more than 200 pounds, or be greater than 24 inches in length or width. The material must be free from excessive rust or corrosion.

No. 3: This material shall consist of miscellaneous mild steel castings. No piece shall weigh more than 200 pounds or less than 25 pounds. The material must not contain malleable or cast iron, must not exceed 24 inches in length or width, and must be free from excessive rust or corrosion.

No. 4—Light Converter Scrap: This material shall consist of mild open-hearth steel scrap, such as punchings, shearings, forge flashings, forge crop ends, etc. The material must be clean and free from excessive rust or corrosion.

No. 5—Springs: This material shall consist of steel springs, including all railroad coil and elliptical springs, but no coil or bar springs shall be under 3/8-inch in thickness or diameter. They must be free from plates. Elliptical springs

must be cut apart and must not exceed 24 inches in length, and the material must be free from excessive rust or corrosion.

Crucible Steel Scrap

This material shall consist of low phosphorus and sulphur boiler and structural steel punchings. Must be clean and free from dirt, tinned and galvanized metal and excessive rust or corrosion.

The above is a basic classification from crucible steel scrap. In the event that any other material be specified, no piece shall exceed 5 inches in width or 8 inches long.

In the event that small soft steel castings shall be specified as crucible scrap the weight shall not exceed 10 pounds nor shall the pieces be greater than 5 inches in width and 8 inches in length, and must be free from malleable, cast iron or other metals.

Electric Furnace Steel Scrap

No. 1: This material shall consist of mild open-hearth steel punchings, but must not include shearings, clippings or other materials. It must be free from tinned and galvanized material of every description, and must also be clean and free from dirt and excessive rust or corrosion.

No. 2: This material shall consist of mild open-hearth steel, such as plates, shapes, structural crop ends, shearings and miscellaneous materials of this character. It must be not less than 1/4-inch in section. No piece shall exceed 12 inches wide and 12 inches long, or weigh less than 10 pounds or more than 60 pounds. The material must be free from excessive rust or corrosion. Bundle scrap and iron of every description will not be accepted.

No. 3: This matterial shall consist of mild open-hearth steel, such as rolling mill crop ends, forge crop ends, and forgings. No piece shall weigh less than 10 pounds or more than 60 pounds. The material must be free from excessive rust or corrosion.

No. 4: This material shall consist of miscellaneous steel tires, broken. No piece shall exceed 12 inches wide or 12

inches long, and the material must be free from excessive rust or corrosion.

No. 5: This material shall consist of high carbon open hearth steel, such as rails, and high carbon or hard steel of miscellaneous character. No piece shall weigh less than 10 pounds or more than 60 pounds or exceed 12 inches wide or 12 inches long. The material must be free from excessive rust or corrosion.

No. 6: This material shall consist of mild open-hearth steel, such as plates, shapes, structural crop ends, shearings and clippings, under 1/4-inch in section. No piece shall exceed 12 inches wide and 12 inches long. Bundle scrap will be excluded, and the material must be free from hoops, cotton ties, wire, etc., commonly known as busheling, together with tinned and galvanized material of every description. It must also be free from excessive rust or corrosion and free of curly material.

No. 7: This material shall consist of carbon tool steel of miscellaneous character, such as files, stub ends of tools, carbon tool steel rollers, wearing plates, etc. No piece shall exceed 12 inches wide or 18 inches long. The material must be free from other metals and excessive rust or corrosion.

No. 8: This material shall consist of steel springs, including all standard railroad coil and elliptical springs. No bar or coil springs shall be under 3/8-inch in thickness or diameter. The springs shall be free from plates and other materials. Elliptical springs must be cut apart and not exceed 24 inches in length. This material must be free from excessive rust or corrosion.

No. 9: This material shall consist of coil and leaf or elliptical springs under 3/8-inch in thickness or diameter. The springs shall be free from plates and other material. Leaf or elliptical springs must be cut apart and not exceed 24 inches in length. This material must be free from excessive rust or corrosion.

No. 10: This material shall consist of heavy turnings from high carbon or hard steel. Open-hearth steel must be

free from light and curly turnings. It must be clean and free from excessive rust and corrosion.

No 11: This material shall consist of heavy turnings from mild or soft open-hearth steel, free from light curly turnings. It must be free from excessive rust or corrosion.

Note: Material coming under all of the foregoing classifications for electric furnace steel scrap, when purchased for the acid process is limited to 0.04 per cent phosphorus and sulphur.

Weights

Net Tons: All scrap bought or sold under these specifications shall be handled only on a net ton basis, said ton to consist of 2000 pounds.

Variations: Variations in weights shall be subject to the regulations of the authorized weighing association operating in the territory to which the material is delivered.

Rejections

The purchaser reserves the right to reject any material failing to conform to these specifications.

In the event of a rejection, all demurrage charges and return freight shall be paid by the seller.

Respectfully submitted,

Benjamin D. Fuller,
G. S. Evans,
David McLain,
W. A. Janssen,
J. G. Garrard, *Chairman.*

The Care of Foundry Equipment

By David McLain, Milwaukee

"Where are we going to secure capable foundry executives; men whose education includes a practical knowledge of metallurgy and the science of melting, molding, molding machines and other labor saving equipment?" asked Mr. Smith, a manufacturer who also owns a foundry.

"What are you doing in that direction?" I asked, and he admitted that they had done little but talk about it at their meetings. At the last session a poll was taken to learn the opinion of those present, but the results were not very gratifying. He said:

"Williams, our manager, believed everything was all right when everybody was doing their bit, but agreed that the labor shortage had retarded their production somewhat."

Jones, the machine shop superintendent, was very severe in his statements concerning the loose methods employed in their foundry. He claimed that the output from the molding machines was only about half, that the castings were hard and that the surface of the castings was dirty although they had a fine sandblast equipment.

The chemist reported everything going along nicely in his department when the iron was poured hot and the different mixtures were properly used; that is, when No. 1 mixture was poured into molds requiring No. 1 iron instead of hard iron in soft castings, and vice versa.

Foundry Not Running Smoothly

He admitted that the cupola was behaving badly but only a few days ago he was fortunate in securing the services of a young man who understood English, to supervise the charging of the cupola, and that, he said, would help some.

He declared that the pig shortage was affecting the quality of their products somewhat as he cut down the pig to 40 per cent. using 60 per cent scrap.

The foundry superintendent took exception to some of the statements made by the chemist. Mr. Smith, the manufacturer, said the meeting ended in a very unharmonious manner and suggested that I visit his plant and discuss the situation with the head of each department in order that we might devise some plan of action.

Smith appeared to think I should interview Mr. Jones, the machine shop superintendent, whom he said was a pretty broadgaged fellow and had studied the foundry operations from every angle. He was a stockholder as well as a director of the company, a forceful, energetic, practical machinist who had worked right up from the bottom.

The Machine Shop Man's Story

Let me tell you his story:

"About 10 years ago we introduced the premium system in the machine shop and endeavored to put it in the foundry, but failed—not because the molders would not adopt it, but because the foreman and superintendent objected to it."

"Why did they object?"

"They claimed it was all very well to increase the speed of my machines, to use high-speed steel and to use portable cranes for medium and traveling cranes for heavy castings, but it required very little extra effort for the machinists to increase their output, while increased production in the foundry meant increased physical exertion for the molders."

"Why didn't you install labor saving equipment in the foundry?"

"We bought power squeezers, various types of molding machines, jar rams, air rammers, pouring devices, new blower, cupola, sand and cinder mills, sand cutter, sandblast, and we then believed we had solved our foundry problems.

"We obtained more perfect castings—more of them—cleaner than before, etc., but in a short time things began to go wrong."

"Before proceeding further, please enlighten me on a few points that are not quite clear. You invested quite a sum in foundry equipment but did you secure experienced operators?"

"I will admit we left that to the foundry executives."

"Are your foundry relations pleasant?"

"Yes."

"Let us visit the foundry."

The superintendent and foreman were very glad to discuss the foundry situation. The foundry superintendent, Mr. McArthur, said: "'We were given a lot of new equipment and a demonstrator for a few days to teach the men how to operate each machine, but not a man in our employ had ever made a mold on a machine, nor understood rigging up for machines."

"I advised that we engage an instructor for the molding machine department—one who would teach the beginners and adjust or repair the machines when out of order. He should also be capable of laying out the patterns or match plates, and such a man would be worth his weight in gold, but as he demanded more salary than I was drawing, both Smith and Jones refused.

"Now a molding machine with patterns well fitted, is a *producer* and *cost reducer* but, if anything goes wrong, they produce bad castings just as quickly.

No Mechanic for Foundry

"They expected me to fuss with sandblast equipment and sand cutting machines, and Jones even refused to transfer one of his mechanics to the foundry payroll in order to keep the equipment in repair, so I handed in my resignation.

"Both Smith and Jones knew my heart was in my work, that I owned my own home and that I would have to leave town, so they refused to accept the resignation and gave me an increase in salary.

"They have not interfered but have given me no assistance, neither in experienced help or in obtaining apprentices for the foundry although they offer fancy inducements to machine shop apprentices. I wanted to indenture apprentices by paying them $10 per week and a bonus, and I would guarantee to make $30-a-week men of them the first year, but nothing doing, as Smith and Jones only got $2.50 per week as apprentices and could not find it in their hearts to pay more than they received.

"Now our chemist is a fine, clean-cut fellow but he did not spend six years in college to become a *melter,* nor will he devote much of his time to the foundry.

"He claims the cupola is in my charge but I maintain that the party responsible for the metal must exercise control over the melting department, and he lets the cupola go hang, which it does at times.

"For some months our iron has been on the dull side. He was using 425 pounds of coke (whether it was high or low carbon) to 4200-pound charges of iron and it was necessary for me to call on Mr. Smith to change that to 525 pounds of coke to 5500-pound charges of iron. Since then we are getting hotter iron and 3 tons more per hour.

"Only a few days ago I went up on the cupola platform and the crew was just finishing a charge. Everybody was chattering; no one was thinking, so they began tossing in pig for the next charge instead of coke.

"The following day I discovered that our metal was low in silicon and manganese and I spent 30 minutes on the cupola platform while they threw in several charges of iron and coke but forgot to add the ferrosilicon and ferromanganese.

"A condition like that is demoralizing but fortunately the chemist happened along in this emergency and I believe realized for the first time the absolute necessity for co-operation.

"Although it is now six years since I have been laboring with the equipment, I maintain that it has cost this firm a fortune by not engaging instructors or inspectors.

Superintendent Irons Out Difficulties

"Here is an ash pit casting for furnaces. A molder and helper made 11 per 10-hour day before we installed that machine. Now a molder and three laborers make 45 castings per day with a record of less than 2 per cent loss. Just how much of my time was spent on that job before we got it going good. I don't know, but it isn't wise to let those fellows run loose or things go wrong.

"Only the other day 20 ash pit castings were lost in *one heat,* so I had to drop everything else and check up, or in other words, learn the cause of the trouble. I found the flask pins on the cope plate to be loose and as the drag had to be turned over, this threw the shift all on one side. The section of castings being only 3/16 to ¼-inch thick, this shift left 1/16-inch of metal in spots, which is entirely too thin.

"The molders had blamed the loss to dull iron, which was not allowed when I checked up and discovered the cause which could easily have been averted if the men had understood how to prevent it, which I hope they do now.

Must Inspect Machinery Daily

"Take a sand cutting machine, for instance. There never was a better investment made in this foundry, but look at the construction of it and then figure what it is up against in the way of mud, dirt, gaggers, etc. If you want to keep that going every night, it must be inspected daily, oiled and kept in good shape.

"Sandblast equipment is as much machinery as the finest lathe, but I ask you to consider the character of the labor employed on each. A fine lathe is well taken care of but how about the sand blast? The machine shop superintendent is capable of repairing and testing the lathe because he knows the construction and operation of same, but how about the sandblast and other complicated equipment in the foundry? The nature of sandblast equipment makes it deteriorate rapidly if not kept up but are you going to depend on the foundry labor to keep it up?

"We have all kinds of trouble with our electric riddles and air hammers. Sand gets into the bearings—and by the way, if you will collect the air rammers every night and lay them in a bath of kerosene, blow out next morning and use a little good machine oil, you will secure better service."

We continued the discussion at luncheon, being joined by Mr. Smith and the manager, Mr. Williams.

The foundry superintendent had his subject well in hand and was allowed full swing until he delivered the following:

"I have studied the conditions in our foundry from every angle and maintain that we can never hope to attain 100 per cent efficiency by studying efficiency or business courses. We require 100 per cent common sense first of all, and should apply it to our problems.

"Take our cupola practice for instance. If the chemist is going to make the mixtures, let him master the science of melting first of all. If the metal is not hot, what's the use of speeding up the men? If the molding machines are not kept in repair, cleaned and oiled daily, and the flask equipment is deteriorating, there will be large casting losses.

"If the sand mixing, cutting and blasting machines, air and electric hoists, traveling cranes, blowers, and other similar machines are not kept in repair the foundry will not receive proper return for the money invested in this expensive equipment, and even though it would be of the most modern type it is not worth much if it is idle part of the time because proper attention is not given to repairs and maintenance."

Proprietor is Finally Won Over

Here the foundry superintendent was interrupted by Mr. Smith, who said:

"Just a minute, this is a new angle to our problem. I don't think I have ever before considered the maintenance problem from the standpoint of return on investment. I think the foundry superintendent has stated the case thoroughly and although I have been opposed to spending too much money on mechanics in the foundry, I believe I am beginning to see that unless some thought and attention is given to the care of this equipment, it might just as well not be taking up space in the foundry."

Turning to Mr. Williams, the manager, he asked:

"Why don't we try this plan that the foundry superintend-
has been trying to adopt all these years? I will admit that
, you and myself probably have been a little too cautious
handling of the problem. We have opposed the foundry
simply because we haven't had the nerve to break away

from tradition. Just because foundrymen in general all over the world have neglected their machinery and equipment ever since they had anything that deserved the name of a machine, is no reason why we should keep on. Here we have thousands of dollars tied up in the molding machines, sand blast apparatus, air compressors, electric cranes and pneumatic tools and yet we are daily entrusting this expensive equipment to the mercies of some of the poorest men we have in the plant.

"Williams, you and I have been using our antiquated methods for the last five or six years; what do you say we give the foundry superintendent a fling at his own scheme?"

Turning to the foundry superintendent, he said: "McArthur, this afternoon we will go to Jones and pick out one of the best all around mechanics he has in his shop. We will transfer this man to the foundry and explain to him that he is to have complete charge of keeping up the machine equipment in that department. He is to have immediate access to the facilities of the machine shop to help him keep the equipment in repair. Moreover, McArthur, you are to arrange some sort of a plan whereby all machine equipment in the foundry is inspected regularly. I believe that if we follow out a systematic plan of checking up this equipment and repairing it before it is too late we shall increase the amount of work which we get out of our machines. Let's try this plan, say for six months, and at the end of that time I believe that the results will be apparent to all of us."

* * *

New Plan Brings Results

The foregoing conversation took place something over a year ago in a well known foundry and machine shop. The plan outlined by Mr. Smith at this little luncheon was put in force that same afternoon. Mr. Smith and Mr. McArthur, the foundry superintendent, secured an old millwright from the machine shop who fit in with the new job almost perfectly. He took pride in keeping the equipment in good shape and before long was boasting of the small amount of lost time caused by foundry machinery breaking down. The result soon

was apparent in the smoother working of the various departments in the foundry and McArthur had the pleasure of seeing his suggestion carried out under favorable conditions.

Williams, who had taken only a lukewarm interest in the proposition at first, soon became enthusiastic over it, especially as his monthly report showed that the charges formerly appearing under the title, "Repairs to Foundry Machines," constantly decreased. In other words, the millwright was more than saving his wages by cutting down the cost of repairs. This was due, no doubt, to the fact that his systematic inspection of various machinery enabled him to correct small defects before extensive repairs were necessary.

The conditions outlined in the above story are typical of those prevailing in many plants in the United States. Many foundrymen have modern equipment but are not getting adequate return for their money simply because they are not utilizing this equipment advantageously. Foundry equipment must be cared for just as conscientiously as the machine tools in the machine shop and as soon as foundrymen break away from the traditional methods of the oldtime foundry and realize that a molding machine should receive as much attention as a drill press or engine lathe, their maintenance troubles will cease. The writer recommends that foundrymen who are having trouble in maintaining their machine equipment follow the example of Mr. Smith and for a trial period of at least six months, allow a reliable mechanic to take the responsibility of keeping the machinery in repair. If this plan is carried out intelligently no progressive foundryman will return to his old slipshod methods at the end of the 6-month period.

The Equipment of the Foundry—Today and in the Near Future

By H. R. Atwater, Cleveland

How to increase production is the great problem of the foundry today. If a careful investigation were to be made it undoubtedly would establish the fact that no industry in a period of time comparable to the past two years has ever invested as large a sum of money in labor saving devices as has been expended by the foundries of this country to increase production and make use of the labor available. Yet this development is still far short of the needs of the times. The demand for every kind of castings has been such that if a foundry could make delivery it could demand almost any price it wished to ask. The foundry has been one of the cramped "bottle-necks" of the country's industry.

Old foundries and new additions to foundries have been equipped with the most modern labor saving devices, and the writer believes we are just fairly started in this business of rebuilding or revamping the equipment and methods of foundries. The next five years must see this development continued and speeded up.

High Wages is Influence

Unquestionably, when farm hands can get $7 a day agricultural implements are in great demand; likewise when the wages of ditch diggers reach $10 a day and they are still hard to get, machinery to increase their effectiveness will be demanded and used. The same rule applies to the foundry. As yet, only a small percentage of the foundries have installed modern equipment, but it will have to be installed, for labor will not be available at a much lower figure for a very considerable time to come, and under competitive conditions the plant with the intelligently selected equipment will have the best of it. It has been well said that—"When life is easy we take things easy. When human labor is cheap we use only human labor

and are content. When life becomes more difficult and labor more expensive men use their brains and that means progress."

The last sentence deserves re-reading and careful consideration—"When life becomes more difficult and labor more expensive, men use their brains *and that means progress!*" To each of us that means, "Will I be progressive and do the thinking, or will I let my neighbor do it and leave me far behind?"

Old Equipment is Handicap

In a paper read at the Boston meeting of this association in 1917 the writer expressed the opinion that foundries operated entirely by hand power would feel the handicap so severely under the wages demanded that they could not stay in the business and compete at a profit against the foundry fully equipped with labor saving devices. Observation of plants and what they have been doing since the time of that meeting confirms the prediction. Wholesale changes are everywhere under way in every phase of equipment and method of production.

The difficulties that the foundrymen have had to contend with during the past three years have been many. Probably the greatest has been the securing of sufficient labor to operate equipment. The unwillingness of available labor to work in a foundry when there has been a wide choice of other kinds of work offered in which the wage paid was large, has made it difficult to man foundries properly. This has been particularly true in many plants that are not of modern construction and where sanitary conditions have not been of the best. It is particularly true that the best individual workers have been especially careful in selecting the best surroundings.

A Test for Your Plant

This brings up for consideration some very vital questions, which might be headed as follows. Not one of these questions is so unimportant that a foundry owner can afford to ignore it or fail to answer it fairly.

Is my business properly housed? Are the various processes in production located and routed so as to necessitate the fewest waste steps?

Are my buildings as pleasant places in which to work as those of neighboring plants? Is the heating right? Are they ventilated to remove disagreeable dust and gases? Are sanitary

conditions good; for instance, are the toilets and the rest room for the women in the core room sufficient and are they properly segregated?

Have I competent foundry foremen and superintendents backed by the necessary mechanical training and skill to recognize, install properly and operate the many labor saving devices used by most progressive competitors?

Are these men actually leaders of my manpower? Are they in the true sense *managers?* Albert Atwood has expressed it in a recent issue of the *Saturday Evening Post:*

> "What does all this mean, except that organizing, that managing ability is very scarce? We talk about organization in a very matter-of-fact, offhand manner, as if it were an easy, simple thing. But we cannot have the goods and service upon which our lives depend without organization, yet how very few of us indeed have the capacity for it!
>
> "Human beings, materials, tools, equipment, working space and appurtenances must be combined. They must be brought together systematically and co-ordinated effectively to accomplish the desired object of providing what the world needs. The human beings in the organizations are always the most important and difficult problem. Yet they are useless without tools and equipment, and the mechanism cannot function and does not function until that force which we call management leads, guides and directs the whole combination, or organization. Management has to pull the lever, and nothing starts until there is a management which creates a spirit, an atmosphere, a set of ideals, enthusiasm, inspiration, a loyalty, orderliness and discipline."

In these times very high wages must be paid even for the most ordinary labor. In many places plants bid actively against each other for such available labor as can and will work in a foundry. For instance a large portion of the molding machine equipment which has been installed during the past several years from necessity has had to be operated by what has been usually termed common labor.

Equipment is Neglected

Waste and inefficiency are prevalent in many plants due to lack of proper mechanically trained men to take care of foundry equipment. It is a fact that in many plants where

thousands of dollars have been invested in equipment it is allowed to operate in dirt and sand, to become rusty from lack of lubrication, or is left standing with very little or no attention in exposed places. It is a wonder that in some plants any operation at all is possible. This criticism is not confined to individual cases; in fact so general is the lack of care of equipment in the industry, that the Foundry Equipment Manufacturers association has taken up the matter and is sending out monthly bulletins in an endeavor to educate men to properly care for equipment. We criticize the farmer who leaves expensive machinery in the open, unpainted, at the mercy of sun, wind, frost and rain, yet we can find equally wasteful habits in our own plants.

The ability to produce castings on modern type machines with the class of help available requires able instructors with mechanical ability, first to rig the equipment properly, and second to operate it effectively. There is a great lack of the right kind of men trained in the use of equipment and pattern rigging and with proper mechanical training to install and instruct others in the working of equipment. Muscle and machinery are useless without brains, not only in the front office and at the superintendent's desk but down on the foundry floor. It is the writer's opinion that we are face to face with one of the greatest needs of the industry at this time. This opinion is based upon the many calls that are made upon equipment manufacturers to recommend and find competent men to handle modern equipment and who can get consistent results day after day, in producing good castings and in producing *more* castings. Men of this type are not running around loose. Good teachers are far less common than good operators. Furthermore we may as well recognize the fact that men skilled along the lines mentioned are not being trained in sufficient numbers to meet the demand. This is a serious matter. The time is opportune to suggest to this organization that it could confer no greater benefit upon the foundry industry of the world than to establish a modern school of foundry practice where men who wish to take up the practical and mechanical work of the present day foundry

may be sent to be educated and schooled in the matter of proper rigging, handling of equipment, cost accounting, etc. In such a school standardized practices could be taught that could be outlined by a faculty of foundrymen to be chosen by this organization.

Operate Plant as a School

The writer believes that a plant organized and operated as a school to which prospective foremen or plant engineers could be sent to serve a definite apprenticeship and turned out with a certificate or diploma, would bring a very large field of employment. This would go a long way towards supplying a very great need in the industry, a need that will be felt more keenly and to a greater degree as competitive conditions bring about a still larger use of machines and various labor saving devices in the foundry. Any step which tends to make an industry more productive and less wasteful of man power is a national service. For that reason I feel that we could all put our shoulders to the wheel on such a project.

Notes On European Molding Machines

By H. Cole Estep, London, England

Most of the molding machine manufacturers of Europe are found in Great Britain, France and Germany, although builders also are located in Scandinavia and Italy. The field, however, is dominated by the three countries first mentioned and within their borders may be found examples of all of the types of molding machines in use in Europe. In addition to the simplest forms of plain squeezer and stripping-plate machines, these types include plain jar-ramming machines; combination jar-ramming and roll-over machines; turn-over machines of the trunnion type with pattern-drawing and mold conveying attachments; pneumatic and hydraulic squeezer machines, with and without roll-over attachments; electric jar-ramming and squeezer machines; and special machines of various kinds.

As in other countries, European molding machines may all be divided into four fundamental classes—squeezer, stripping-plate, roll-over, and jar-ramming, various combinations of these functions being worked out in individual machines. But although the fundamental principles are the same, there are wide differences in the methods of applying these principles, as between machines built in the United States and most European countries. Many European molding machines, therefore, have a decidedly strange appearance in American eyes.

Purpose of the Paper

It is the purpose of this paper to describe and illustrate some of the principal types and styles of British, French and German molding machines, in order to try and bring to the western world a clearer idea of their design and methods of operation than has prevailed heretofore. Many of these machines present features and advantages which are well worthy of study by American foundrymen. It is the purpose of the author to present the subject almost entirely from the descrip-

tive standpoint and no effort has been made to write a critical essay. Discussion of the relative merits and advantages of American and foreign machines also has been avoided for obvious reasons, chief among which is the fact that operating conditions and the labor factor are so divergent on the opposite

FIG. 1 BRITISH HAND SQUEEZER MACHINE FOR SMALL CASTINGS

sides of the Atlantic, that it would be difficult if not impossible to make criticisms fairly. Readers of this paper should perhaps be cautioned, when studying the types of machines to be presented, to bear in mind that they have not been designed for American foundries, although many of them contain features which might be applied, with some modifications, to American practice. Finally, it should not be assumed that this paper is

in any way complete or comprehensive. Lack of time, and the writer's limited experience in Europe, have prevented anything in the nature of an exhaustive study. The paper is offered merely for what its title indicates—a series of descriptive notes on European molding machines, showing perhaps to some degree the progress which was made in design and construction during the war period.

As a matter of fact the war did very little for the development of the molding machine in Europe. Everyone concerned was too closely tied down by insistent demands for production to have any energy to spare for experimental work or new developments. Most of the progress made during the war was in the direction of adapting existing machines to cast-shell and grenade production. In the two years since the armistice, however, a number of new types of machines have been brought out, especially in Great Britain.

British Molding Machines

Great Britain is one of the leading producers of molding machines in postwar Europe. Her machines reflect inventive genius and independence of precedent; their development has been stimulated by the growth of the motor-car industry in the United Kingdom and by the great demands of the British shipbuilding industry for quantities of heavy iron and steel castings.

A large number of plain squeezer machines, with the conventional swing-back head, are made in England. A typical machine of this character is shown in Fig. 1. It has a hand-lever squeeze by means of which a pressure of about one ton can be applied to the mold. No detailed description of this device is necessary.

Owing to the fact that even in the largest British foundries operating on a quantity production basis the multiplicity of designs makes frequent changes of pattern and flask equipment necessary, a widespread demand has grown up for an adjustable molding machine which can be readily adapted to a large number of different sizes of flasks. To meet this demand, the machine shown in Fig. 2 has been produced. It is one of the most widely used European machines in the small-castings field.

inches in width. A larger size machine is adjustable for flasks between 18 and 26 inches. The machines have a 6-inch draw. Turn-over and 12-inch lift attachments also are provided. Flasks over 30 inches in length can be handled.

The pattern-drawing mechanism is worked by the handle *N* which is connected to the drawing stools *S* through gearing working on splined shafts. Therefore in adjusting the machine to flasks of different widths, the pattern-drawing mechanism is unaffected. The working parts are totally enclosed and run in lubricants. This is done to insure a smooth and accurate draw.

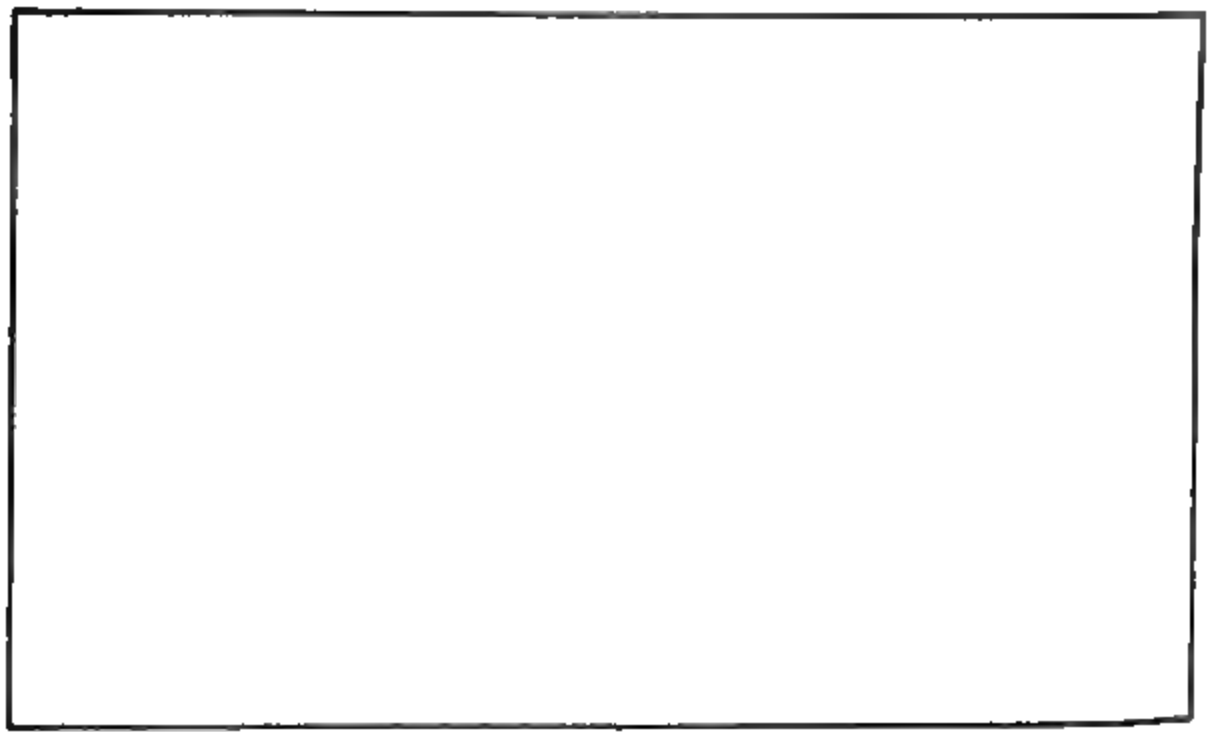

FIG. 5 OPERATING DETAILS OF ADJUSTABLE MOLDING MACHINE

These machines in fact are built and fitted along the lines of a machine tool. This feature, it may be said, is characteristic of British molding machines in general. An effort seems to have been made in many cases to raise them out of the rough-and-ready class and to make machines in the true sense of the word.

Making Motor-Cycle Cylinders

Fig. 3 shows an adaptable molding machine of the type previously described arranged with a double lift attachment for molding air-cooled motor-cycle engine cylinders. The box sets on the flask rests during the ramming operation. The fins are

mounted on a pattern-plate and are drawn through the stripping-plate as shown. When this operation is completed the flask or molding-box as it is called in England, is lifted clear of the stripping-plate. By operating the lever, the fins are then brought back to their normal position, and the machine is ready for the next mold.

For making vertical green-sand cores these machines are fitted with stooling arrangements of the ordinary type. Other views of adaptable molding machines are shown in Figs. 4 and 5, of which Fig. 4 shows a machine with turn-over attachment and draw rails for drawing the finished mold out from under the machine.

Pneumatically operated squeezer machines of the ordinary types are manufactured in Great Britain. Also a large number of hand-squeezers with various types of multiplication gear are turned out. A machine of this latter type is shown in Fig. 6. Its general construction is similar to that of the ordinary squeezer machine, except that it is provided with a mechanically geared head, which enables a pressure of five or six tons, it is stated, to be easily applied to the mold by pulling on the levers *L*. The height of the central column, which supports the flask rest, can be adjusted by the side lever *V*. This machine is designed for flasks 11 x 14 or 14 x 16 inches, the depth of ram being 7 inches and the height of lift 8 inches.

Jar-Ramming Machines

Jar-ramming machines of various types, are extensively produced in Great Britain. Their design in general appears to be more along the established lines with which the American foundryman is familiar than most other European machines. British jar-ramming machines are mainly of the pneumatic type, although recently electrical machines and some ingenious combination electric and pneumatic machines have been developed.

A typical British plain jar-ramming machine of the smaller size is shown in Fig. 7. This machine was developed during the war for use by women. It is pneumatically operated and its air consumption is stated to be six cubic feet of free air per minute. Air at 80 pounds pressure is required. The table is 17 x 21 inches and the lift is 6 inches. It is designed to

handle molds weighing up to 600 pounds, and is especially adapted to core molding. The flask is guided at the corners by the vertical rods shown which are seated in adjustable slotted arms. The capacity of this machine is given as 130 molds per 8-hour day.

The demand in the United Kingdom for large quantities of marine engine, ship and other heavy castings has led to the

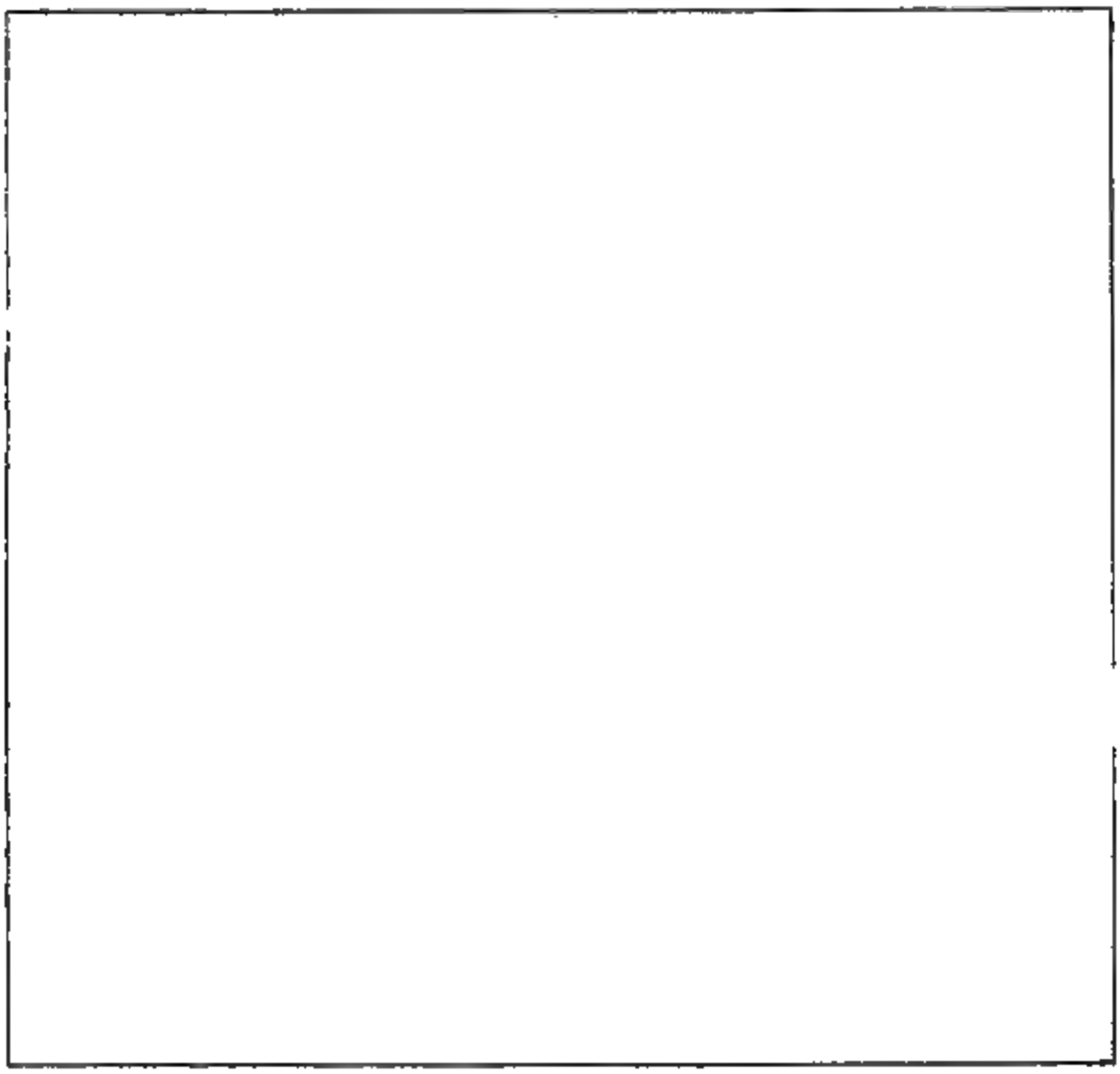

FIG. 7—SMALL BRITISH JAR RAMMING MACHINE, FITTED WITH ADJUSTABLE STEEL RODS FOR HOLDING FLASK WHILE TABLE IS LOWERED TO DRAW PATTERN

construction of jar-ramming machines of the largest size. A very large British machine of this type, fitted with a turn-over table, is shown in Fig. 8. The table, which is of 2 1 8-inch armor plate, is 6 feet wide and 10 feet long. These machines also are built with 7 x 14-foot tables The large machine is designed to jar-ram and roll-over molds weighing up to 10

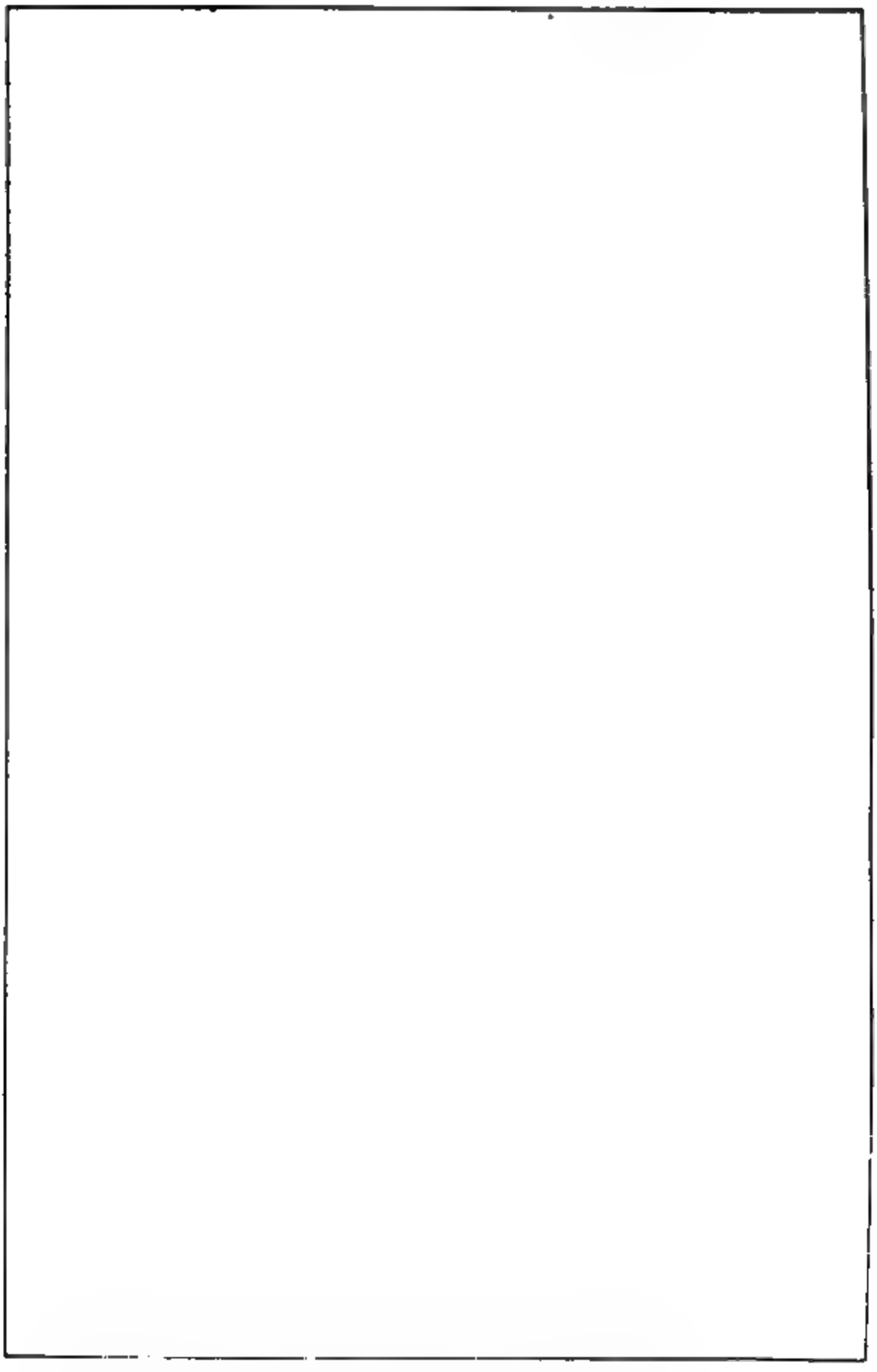

FIG. 8.—A LARGE BRITISH JAR RAMMING MACHINE WITH A CAPACITY OF 15 TONS

gross tons, with 80 pounds of air. The jarring cylinder is 24 inches in diameter and under full load the machine gives three blows per second. The impact is taken on eight jarring columns arranged four on each side of the machine as shown. Four 10½-inch cylinders are provided for lifting the mold for turning over, or for drawing the pattern. Two of these cylinders are placed at each end of the machine. They are connected by a link motion to insure uniform action. The valve on the main cylinder is designed so the air may be discharged gradually if desired. Therefore, the pattern may be drawn either by letting the mold drop away from the pattern, or by drawing the pattern out of the sand with the 10½-inch drawing cylinders. The table is turned over by a bronze worm gear shown in the background in Fig. 8. It is said that only 10 pounds pressure on the hand wheel is necessary to turn-over the mold. The worm wheel is out of gear when the table is in the jarring position.

A machine somewhat similar to that illustrated in Fig. 8 also has been designed with an electric jarring mechanism of the cam type. With a 10-horsepower motor, this machine handles flasks up to four tons. The table is 12 feet long and 3 feet wide, the machine having been built for special work, and pneumatic drawing cylinders are provided.

Electropneumatic Machine

An electropneumatic jar-ramming machine is now being built in England. It is perhaps the most recent machine developed in Europe and possesses a number of new features. It is of the jarring and pattern-drawing type and was designed originally to handle heavy motor-car cylinder molds, although of course it may be applied to any class of work. A view of this machine is shown in Fig. 9.

The machine is built in various sizes, what may perhaps be termed the standard size being fitted with a 24 x 26-inch table. This machine is designed to handle molds weighing up to 1600 pounds with a 5-horsepower motor. The jarring table is mounted on a plunger fitted in a cylinder in the usual manner. The motor, which is bolted to the base of the machine, is geared to a plain eccentric which in turn operates a

The table is lifted only a short distance. The tripping cam is driven by a hand crank through a chain gearing, and since the machine is not designed for large flasks it is not difficult to operate. The rammed mold is also turned-over by the hand crank, suitably counterbalanced, and deposited on a pattern-drawing table which is supported by a plunger resting on an adjustable spiral spring. This spring is so adjusted that the weight of the mold draws it away from the pattern when the

FIG. 11 A MACHINE FOR MAKING PISTON CORES

clamps are released. The purpose of the designer has been to produce a practical machine which can be sold cheaply to automobile foundries and others handling light work. If desired, an electric motor can be substituted for the hand crank.

Special British Molding Machines

It is not possible, within the limits of this paper, to describe all of the various types of special molding machines which have been developed in Great Britain. A few, however, can be referred to briefly.

also carries a bridge piece which in turn supports the dividing pin. This pin is tapered and is held in the proper dividing hole by a spring. A table showing the proper dividing holes to be used has been worked out for molding gears containing from three to 300 teeth. Other combinations of course can be worked out mathematically.

Piston Molding Machine

A special machine for molding piston cores for automobile engines is shown in Fig. 11. A split core box, the two halves of which slide on steel guide rods, is provided. In Fig. 11, the core box is shown on the right-hand side of the machine in position ready for ramming. After this is done, the box, which is counterweighted, is turned over, and by means of the lever the box is opened, leaving the finished core on the core-receiving stand shown at the left. The balance weight is adjustable.

British railways use bull-head rails which are supported in cast-iron rail chairs, instead of employing flat-bottom rails which can be spiked direct to the ties as in the United States. A very large tonnage of these rail chairs is made every year in the United Kingdom. Fig. 12 shows a special roll-over type molding machine which has been developed for this work. The chairs are molded three in a flask as shown, a special tapered flask being used. The flask is rammed by hand, and after it is rolled over, the patterns are stripped out of the mold by a simple drawing mechanism mounted on the back of the roll-over plate. To take care of the back draft in the jaws of the chair, the pattern is provided with two loose pieces, *P*. The spike holes are formed by green-sand cores which are supported during the stripping operation by fixed stools on the back of the plate. The method of gating is shown at *G*, Fig. 12. This illustration shows the method of making the drags. Plain flat copes, which are molded by hand, are employed. One of the cope-molding stations is shown in Fig. 13. As this illustration indicates, the molds are handled in trains and are moved forward from the molding to the pouring stations on small hand-operated trucks.

German Molding Machines

Germany is an important factor in the European molding-machine field, but very little has been published regarding developments in this country for the past six years. A few notes on modern German molding machines accordingly have been collected. German machines fall into the general classifications enumerated in the introduction to this paper. Hydraulic pressure, however, is favored for ramming the molds, and various types of hydraulic squeezer and combination hydraulic-squeezer

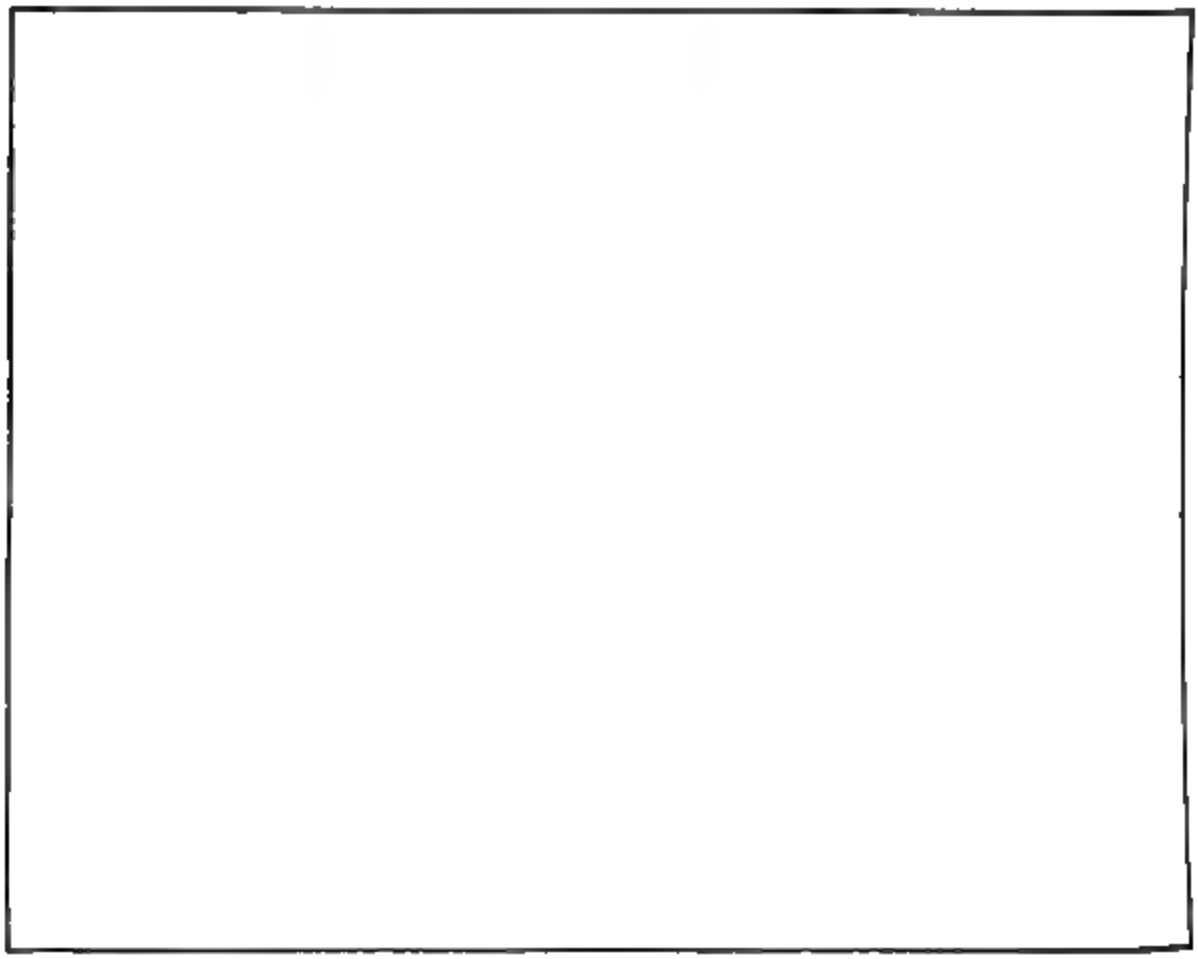

FIG. 14 GERMAN HAND SQUEEZER DESIGNED TO WORK MATCH PLATES

and roll-over machines are built. A new feature is an electric squeezer machine which will be described later.

One of the most common types of German molding machines for light work is illustrated in Fig. 16. The mold is rammed by hand, the flask being placed on the upper table, which swings in trunnions. After the flask is rolled over, the pattern is drawn by manipulating the hand lever shown at the

FIG. 15.—AN ELECTRIC SOLDERER MACHINE OF THE TWIN TYPE

day. A plain roll-over machine, using a match-plate, and arranged for hand ramming, is shown in Fig. 17. The frame is curved so that the mold-trolley may be dispensed with. The pattern is drawn by lowering the receiving table by means of the weighted hand lever shown at the left.

A plain stripping plate machine rigged up for molding air-cooled motor-cycle engine cylinders is shown in Fig. 18. The sand is rammed by hand. The stripping mechanism is operated by the hand lever shown on the front of the machine.

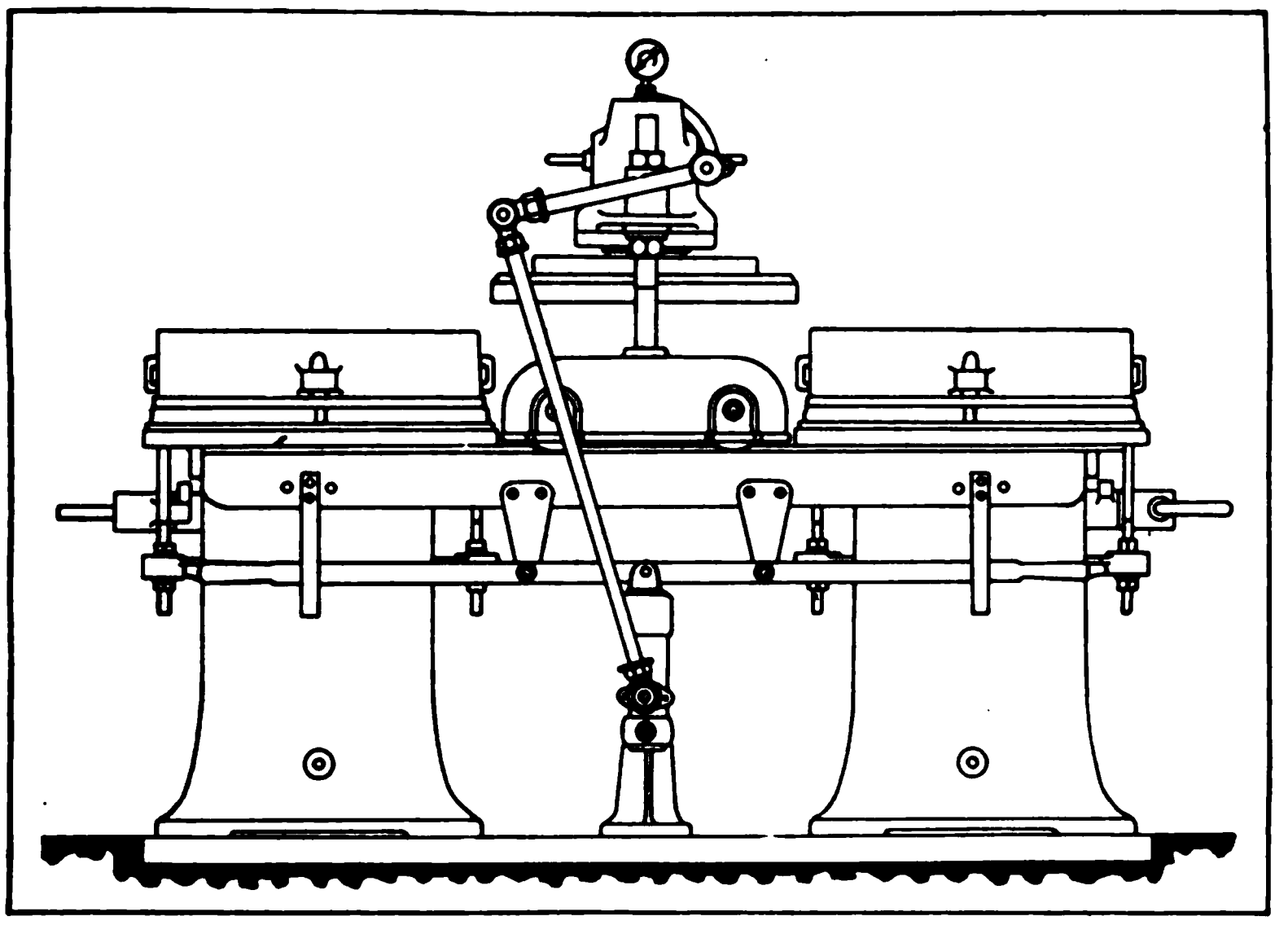

FIG. 20—A DOUBLE HYDRAULIC SQUEEZER MACHINE

The table is fitted with extra long, machined guide pins, by means of which the flask is drawn off the pattern accurately after the fins have been stripped out.

A double hydraulic squeezer machine for molding two flasks at one time is shown in Fig. 20. This machine is designed for molding flat pieces and with two men the output is said to be 80 flasks in seven hours. The flasks are 20 x 20 inches. The patterns are drawn by lifting the flasks off of long machined guide pins. One man works on each side of the machine, a single traveling, hydraulic squeezing head being

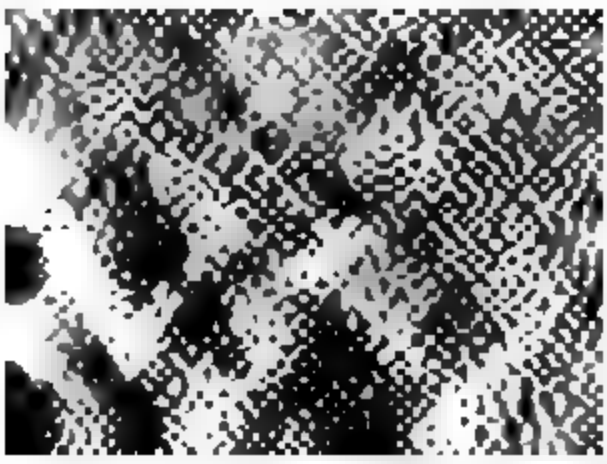

FIG. 21—AN ELECTRIC JAR-RAMMING MACHINE WITH TURN-OVER TABLE

FIG. 22—A GERMAN SHOCKLESS JARRING MACHINE, ELECTRICALLY DRIVEN

provided. It is traversed on the trolley shown in the illustration and may be placed in position when either mold is to be rammed. The water is led to the squeezing cylinder through articulated pipes provided with stuffing boxes.

FIG. 23—PNEUMATIC ROLL OVER JAR RAMMING MACHINE OF GERMAN DESIGN

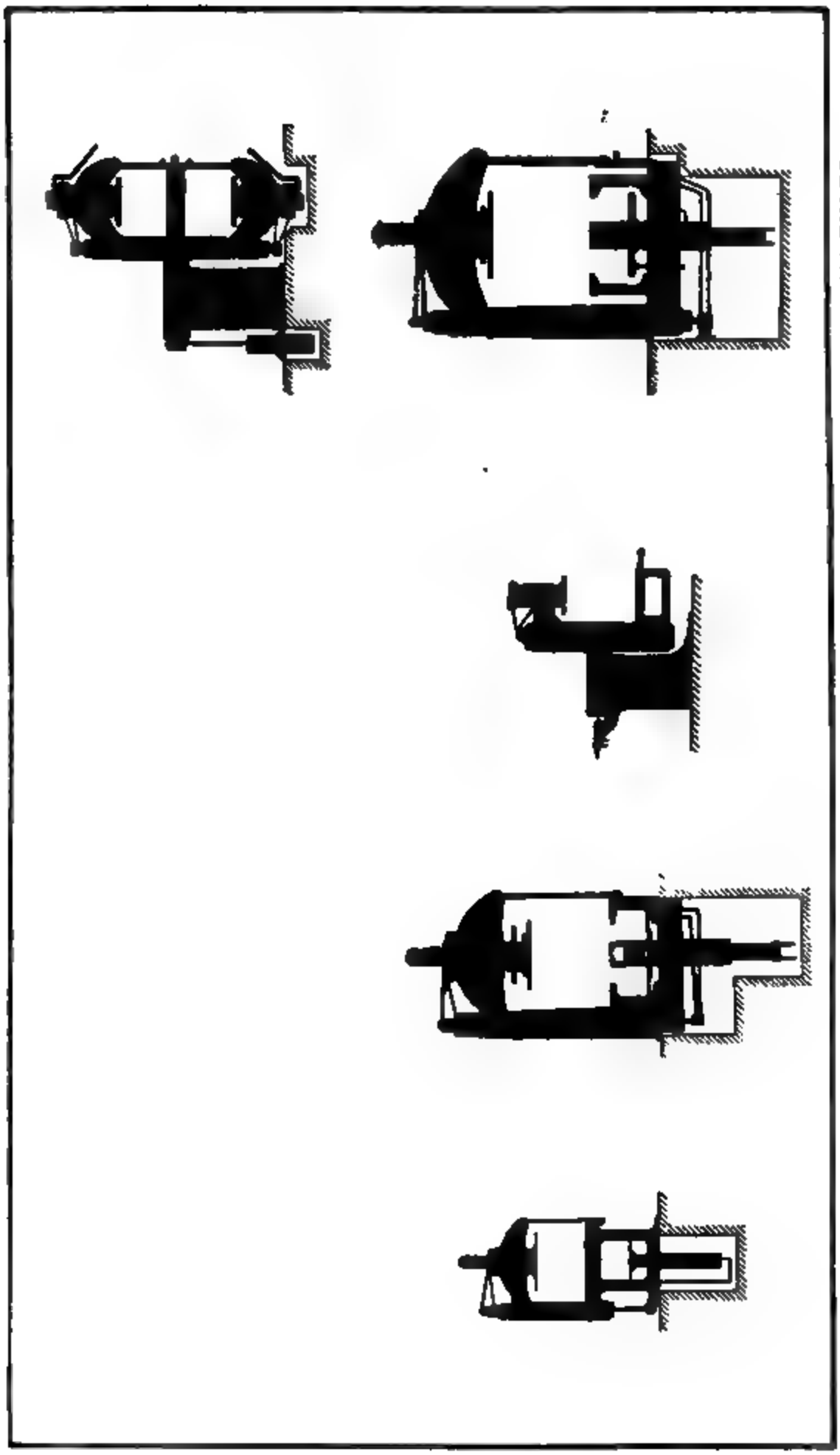

FIG. 26.—SILHOUETTES OF FRENCH HYDRAULIC SQUEEZER MACHINES OF VARIOUS TYPES

An interesting modification of the foregoing machine, substituting electric for hydraulic power is shown in Fig. 19. This machine takes flasks 16 x 20 inches in size and is operated by two men as shown. A production of from 20 to 25 molds per hour is claimed. The machine is designed for shallow work and the drags are molded on one end and the cope on the other. The pattern is drawn by means of long pins as previously described. The squeezing head travels from one side of the machine to the other on rails. The ramming plungers are located underneath each flask in the base of the machine and are engaged with the motor by means of the foot levers placed within reach of the operators. The squeezing head is cushioned with spiral springs. When the head is rolled to the central position, the motor engages a linkwork mechanism which lifts the flask off the bottom-board and thus draws the pattern.

Electrically Driven Machine

Another electric machine is shown in Fig. 21. It is of the electrically driven jar-ramming type, employing the usual cam lifting gear. This machine is provided with a turn-over table and pattern-drawing device. A shockless feature is introduced by cushioning the striking anvil on heavy spiral springs. A deep-drawing electric-driven shockless jarring machine with roll-over table is shown in Fig. 22. The method of cushioning the anvil block by springs is clearly shown. This machine is designed to take flasks 24 x 28 inches and to draw patterns up to 16 inches deep. A double mold-trolley is provided for handling the flasks.

A hydraulic combination jar-ramming and roll-over machine of German construction is shown in Fig. 23. This machine takes flasks 56 x 60 inches in size and has a pattern draw of 28 inches. Compressed air at about 85 pounds per square inch is employed. The anvil block is mounted on springs in the usual German fashion. The pattern-drawing cylinders are of course pneumatically operated and the table turn-over gear works through a worm and wheel.

chine shown at the right. The back plate of the pattern is tilted out of the way before the rammed mold is lifted off.

A machine for molding kitchen pots is shown in Fig. 25. As this illustration indicates, the mold in this case is made in a three-part flask, the cope being split through the center. The interior of the pot is formed by a large green-sand core which is supported on the drag. The drag-molding machine, which also forms this core, is shown at the left. It is of the hand-ramming roll-over type. After the sand is rammed, the flask is rolled over and the two halves of the pattern are then drawn away from the core, releasing the drag so it can be set on the floor. The cope, which forms the outer part of the pot, is molded in two parts on the stripping-plate machine shown at the right. The pattern is stripped through the vertical plate. It is said two men can mold 60 medium sized pots per day.

French Molding Machines

Molding machines are made in France by three or four manufacturers. The usual types of plain stripping-plate and lever operated swing-head squeezer machines are produced. Jar-ramming machines do not appear to be made in quantity. By far the majority of the French molding machines are of the hydraulic squeezer type. Machines of this type have been developed to a high state of perfection. A number of interesting silhouettes of these machines are shown in Fig. 26. Figs. 27 and 28 show another type of French hydraulic machine specially adapted to plate work with an aim to high production. On flat work outputs up to 350 molds in 8½ hours have been recorded. As these sketches indicate, the machines fall into two general classes, namely, rotating head, or turn-over machines so designed that the entire machine may be rotated on a horizontal axis by hydraulic power.

Adapted to Wide Range of Work

The French machines are adapted to a wide range of patterns. They are specially suitable, however, for match-plate operations and many of the machines are so designed that both the copes and drags may be squeezed at one time. These machines are provided with two hydraulic squeezing cylinders

located at the top and bottom respectively, so arranged that they may be employed, after the mold is rammed, to draw both halves of the flask away from the stationary frame holding the match plate. The latter rotates around the main column of the machine and may readily be swung out of the way as soon as it is disengaged from the mold. This permits the two halves of the mold to be brought together again. The top squeezing head can now be swung to one side and the mold pushed bodily out of the flasks by the bottom cylinder. In this way a small amount of flask equipment is made to serve for a large floor of molds, following the principle of the snap flask. In these cases the machines are operated in connection with push-out stools, shown in Fig. 28, by means of which the assembled mold is pushed out of the flask and set on the floor for pouring.

No Machining on Match Plates

The match plates are made of white metal from master patterns. They are so designed and molded that no machining is required in their production; nevertheless accurate patterns are produced.

Where the flask must be rolled-over for drawing the pattern, the frame carrying the hydraulic cylinders is mounted on a trunnion bearing which is so arranged that the machine may be turned-over bodily and turned back again by its own hydraulic power. The water in this case is led to the cylinders through the trunnion shaft, which is hollow.

French machines are adapted both to jobbing and manufacturing foundries and types of machines have been developed to cope successfully with every problem which may be encountered in the molding room.

Discussion

The Chairman, MR. C. R. MESSINGER.—I followed Mr. Estep through Europe when he was making his investigation. I went over to see the proprietors of certain malleable plants and was surprised to find the average production during the war

was 160 pounds per man per day. In our plant in America we would have to shut up shop if our average production dropped to less than 400 pounds per man per day. It was interesting to look into the wage situation and to study the cost of labor. At that time, molders were getting about 27 cents an hour and malleable molders were getting in the neighborhood of 70 cents an hour on piece work.

We hear a lot about the merchant marine and about the ability to handle export business. If we knew how to handle export business the way the average automobile concern does, it would be possible for the American malleable industry to send men to Europe and sell castings. That is an unusual statement, though it is exactly what I found. However, I cannot state how long these conditions will exist.

Core Baking in Electrically Heated Ovens

By Jesse L. Jones, East Pittsburg, Pa.

The core department of most foundries has received too little attention in the past. This especially is true of the ovens used for baking cores. The average oven that is fired by gas, oil, coal or coke, has neither insulation nor temperature control. Hence it wastes fuel and incurs losses from overbaked or underbaked cores and from inability to speed up production without endangering the quality of the product.

While it is not the purpose of this paper to discuss in detail either the various methods of electrically heated core ovens or of automatically controlling them, it will be of interest to give a brief description of a new thermostat that is reliable and comparatively inexpensive. The control element consists of a strip of porous refractory material impregnated with a substance that is nonconducting up to a given temperature and conducting above that temperature. The porous strip is supported by silver terminals and connected with a suitable relay, motor-driven switch and small transformer, the last named three pieces of apparatus being assembled in one self-contained unit. The impregnating materials not only will regulate at the temperature required for core oven work but are capable of controlling any temperature from 150 degrees Fahr. to 1450 degrees Fahr., with possibilities above and below these points.

The following tests were made to determine what would be satisfactory baking conditions for the electric core oven and to ascertain some of the advantages of this oven over fuel heated ovens. It was not intended to study any particular type of oven but to investigate some of the advantages of electric heat in an oven where ventilation is regulated carefully, the temperature controlled accurately and the heaters so placed as to give a uniform temperature in all parts of the oven.

Used Commercial Oven

The oven used was a draw-shelf, commercial type. It was 5 feet 8 inches x 6 feet 8 inches deep and 7 feet 6 inches high, of sheet steel construction, with walls about 4 inches thick, fairly well insulated except on the bottom where the concrete floor allowed the escape of considerable heat. The oven was equipped with a fan driven by a variable speed motor and so arranged that the air could be exhausted or re-circulated or a portion could be exhausted and the remainder re-circulated. Accurate thermostatic control was provided. Figs. 1, 2 and 3 show views of the oven, while Fig. 4 gives the chart of a representative day's run.

Three core mixtures were experimented with, as follows:

	3 Molding Machine Work Per Cent	4 Heavy Bench Work Per Cent	7 Splicer Cores Only Per Cent
Silica sand.....	63.95	16.03	97.30
Molding sand.....	21.35	....	....
Sand blast dust.....	11.88	19.60	....
Old core sand.....	....	64.14	....
Oil	1.78	....	2.03
Dextrin	1.04	.23	.67

As it was desired to ascertain the conditions under which cores of the best quality could be produced, a number of runs were made on each of the above mixtures, varying the temperature and time of baking. Test cores of two kinds were used to judge of the thoroughness of the baking. These were tensile specimens using the regulation brass molds designed for making blocks for cement testing; and compression, using a 2-inch cube. A compression and a tensile test piece was placed on the top, middle and bottom shelf with each lot of cores.

Preliminary Heats Made

Previous to making the tests, a number of runs were made to determine what would be a satisfactory ventilation of the oven. It was run at a constant temperature of 400 degrees Fahr., and loaded with weighed charges of production

air pressure being registered by pitot tubes. The change of air was obtained by calculation from the volume of the oven, pressure and temperature of the air exhausted and re-circulated. Re-circulating the air 30 times per hour was the rate decided upon and used in the tests made.

The average results on the three core mixtures were as shown on page *7*.

The results obtained on the comparative tests made show that the electrically heated oven produces cores having from 50 to 200 per cent more strength than the fuel fired ovens. In baking large cores containing oil, it is customary to heat at a low temperature at first to allow the moisture to escape before the oil hardens. However, the first tests on No. 3 core mixture showed that this is unnecessary on small cores.

Moisture Not Harmful

The excessive moisture, 26.70 per cent, which was found on run No. 2 for the core sand, did not crack the cores nor injure them in any way. However, it is undesirable, as energy is wasted in expelling it.

An inspection of the results obtained indicates that baking at 450 degrees Fahr. for somewhat less than one hour, gives the best results. The dextrin binder seems to be weakened by prolonged baking above 400 degrees Fahr. However, at 400 degrees Fahr., overbaking 50 per cent or more does little harm. One lot of oil cores baked over night by neglect to turn off the current, were found to be of good quality When forcing an oven at a high temperature, an alarm clock is useful to indicate when the cores should be removed to prevent overbaking and waste of heat.

It was found that the weight of the cast iron core plates was almost equal to the weight of the cores. It is desirable to reduce the weight of the core plates to the minimum consistent with stiffness. However, the current loss due to heating these plates is only about 20 per cent of the radiation loss of the oven.

The oil used in the test was a compounded oil containing mineral oil. Stronger cores would have been obtained with pure linseed oil.

COMPARATIVE TESTS IN AN ELECTRICALLY HEATED OVEN

No. 3 CORE MIXTURE

Run No.	Degrees Temp. Fahr. Initial	Final	Time Hours	Crushing Load Lbs.	Tensile Strength Lbs.	% Moisture in Core Sand	Baked Cores	Power k.w.h.
1	300	300	3	253	21	5.74	.18	40
2	300	350	2½	500	50	26.70	.12	30
3	300	400	1½	1712	192	5.44	.13	30
4	300	450	1½	1739	187	5.44	.13	40
5	300	500	1½	1244	166	5.44	.12	50
8	450	450	¾	1965	121	5.44	.16	20
9	500	500	1	1516	142	5.44	.11	20
			No. 4 CORE MIXTURE					
10	450	450	1	1171	87	6.38	.18	20
13	350	350	1½	776	46	6.38	..	20
14	450	450	1¼	1550	142	6.38	.14	30
15	300	300	1½	675	66	6.47	.13	20
16	350	350	2	802	95	6.47	.16	40
17	400	400	1	906	88	6.47	.14	20
18	400	400	1½	1206	105	6.47	.16	20
			No. 7 CORE MIXTURE					
19	300	300	1	815	97	....	..	20
26	400	400	1	1856	182	....	..	30
27	400	400	1½	2209	194	....	..	40
28	400	400	2	3854	342	....	..	50
29	350	350	1	754	66	6.13	..	20
30	350	350	1½	1313	118	6.13	..	30
31	350	350	2	2690	180	6.13	..	50

COMPARATIVE TESTS IN A CONTINUOUS OVERHEAD GAS HEATED OVEN

No. 3 CORE MIXTURE

Run No.	Degrees Temp. Fahr. Initial	Final	Time Hours	Crushing Load Lbs.	Tensile Strength Lbs.	% Moisture in Core Sand	Baked Cores	Power k.w.h.
6	...	...	2	467	62	5.44	.12	..
			No. 4 CORE MIXTURE					
11	...	...	2	776	65	6.38	.14	..
32	...	...	2	677	87	6.17	..	..

COMPARATIVE TESTS IN AN OVEN FIRED WITH GAS AND OIL

No. 3 CORE MIXTURE

Run No.	Degrees Temp. Fahr. Initial	Final	Time Hours	Crushing Load Lbs.	Tensile Strength Lbs.	% Moisture in Core Sand	Baked Cores	Power k.w.h.
7	...	...	25 min.	832	140	5.44	.16	..
..	...	...	2½	1519	102	....	..	..
			No. 4 CORE MIXTURE					
12	...	...	1	833	57	6.38	.09	..
..	...	...	2	779	78	6.38	.16	..
			No. 7 CORE MIXTURE					
34	...	...	3	1167	110	6.17	..	..
..	...	...	3	1334	101	6.17	..	..

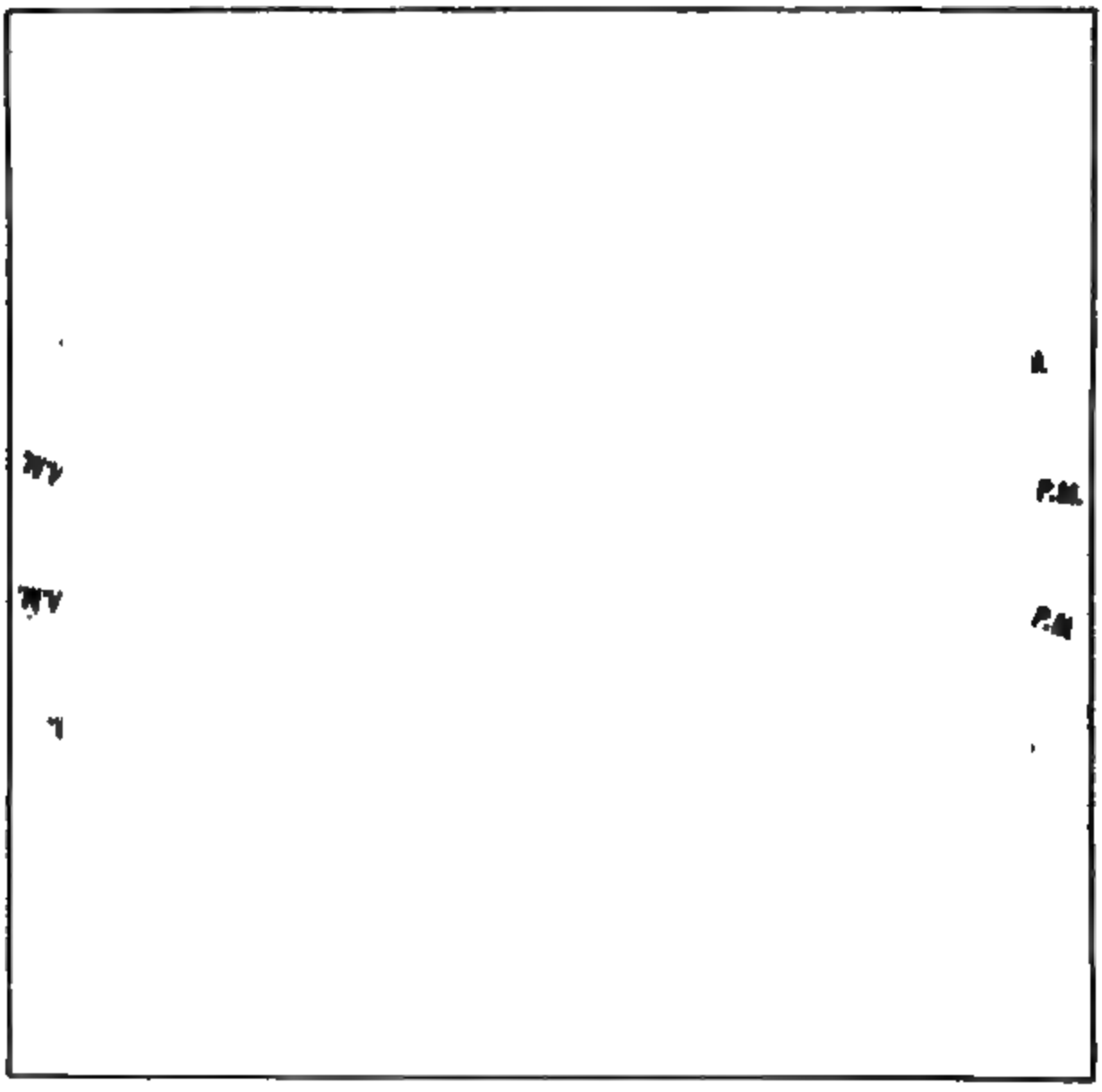

FIG. 4—THE CHART DEMONSTRATES THE RAPIDITY WITH WHICH THE OVEN IS BROUGHT TO MAXIMUM AND THE EVEN TEMPERATURE MAINTAINED

compounds irritating and injurious to the eyes and nose also are present. In many foundries the core room force consists of young girls This class of labor is especially susceptible to fumes and hence electrically heated core ovens are not only desirable in such situations but absolutely necessary if the labor is to be kept efficient. With imperfect combustion we also find soot being deposited on the walls of the core oven and on the cores themselves.

The following conclusions can be drawn from the test of this electrically heated core oven

1. Uniformity of Temperature—A practically uniform temperature can be obtained in all parts of the oven.

2. Control—The temperature can be held to within 5 degrees Fahr. plus or minus any desired temperature.

3. Comparative Freedom from Gases—The only gases given off by the electric core oven come from the core compounds used. These gases are not excessive in amount or dangerous in character.

4. Conditions of Baking—Small oil, dextrin, or oil and dextrin cores can be satisfactorily baked in less than one hour at 450 degrees Fahr.

5. Quality—The cores when baked in the electric oven are from 50 to 200 per cent stronger than when baked in the fuel fired ovens.

6. Speed—A greater input of heat units is possible in the electric core oven without injury to the cores than is possible in fuel fired core ovens.

7. Power Consumed—While no attempt was made to obtain an accurate reading of the power consumed in making the tests, it is estimated that about 12 pounds of green cores were baked for each kilowatt hour.

Report of Committee on Safety, Sanitation and Fire Prevention

Your committee on safety, sanitation and fire prevention has been active during the past year on work of importance to the foundry industry. Early in the year 1919 the United States bureau of standards called to Washington representatives of a number of national organizations as well as representatives of organizations of importance not national in their scope, to consider the question of uniform safety standards. All agreed that there was a growing number of safety standards on different subjects formulated by state authorities, insurance rating bureaus and organizations and that it would be desirable to bring these standards into uniformity to avoid as much as possible conflicting standards. As a result of these meetings it was decided to refer the question to the American Engineering Standards Committee, which committee had been organized some two years previous to deal with engineering standards by five large engineering societies—civil, mechanical, electrical, mining and the Society for Testing Materials, and the government departments of war, navy and commerce. This committee was further enlarged to embrace fire protection interests, the National Safety Council and organizations interested in standardization. It was agreed that this American Engineering Standards Committee should have general supervision over the formulation of safety standards; the committee itself, however, not to formulate codes. A smaller committee including representatives of the National Safety Council, Bureau of Standards, American Society of Mechanical Engineers, National Electric Light association, Underwriters Laboratory, Safety Institute of America and states having adopted codes was appointed to choose sponsor bodies to pass upon codes submitted by these sponsors and if unanimous in its approval of a code its work to be accepted by the Engineering Standards Committee and code to receive their O. K. without further investigation.

This committee accordingly on April 12, 1920, requested the American Foundrymen's association and National Founders association to act as joint sponsors in the formulating of a foundry safety code. The American Foundrymen's association, through its committee on safety, sanitation and fire prevention, with the approval of your president, accepted sponsorship. Similar action was taken by the National Founders' association. The American Foundrymen's association committee appointed by your president, comprised the following, viz.:

Ralph West, West Steel Casting Co., Cleveland.
C. H. Gale, Pressed Steel Car Co., McKees Rocks, Pa.
F. H. Elam, American Steel Foundries Co., Chicago.
J. O. Houze, National Malleable Castings Co., Cleveland.
Victor T. Noonan, Quincy, Mass.
Benjamin D. Fuller, Defiance Paper Co., Niagara Falls, N. Y.

The personnel of this committee was submitted to the American Engineering Standards Committee and recognized by them.

A joint meeting of the committees of the American Foundrymen's association and National Founders' association, was held at Niagara Falls, N. Y., July 27. The American Foundrymen's association members in attendance were Ralph West, C. H. Gale, F. H. Elam and B. D. Fuller.

The National Founders' association was represented by H. J. Boggis, chairman of their committee. After due deliberation it was decided to submit to the American Engineering Standards Committee the existing code as adopted by the American Foundrymen's association and National Founders' association, 1917. This was done by submitting to P. G. Agnew, secretary, American Engineering Standards Committee, the following:

"The American Foundrymen's association and the National Founders' association, joint sponsors for the foundry code, present herewith through their respective committees on safety and sanitation, their foundry code for adoption as the *Standard Foundry Code.*

"We enclose a brief history of the preparation and adoption of this code by the entire membership of both associations, together with five (5) copies of the code.

"The men who served on the committees which prepared this code

were practical and prominent foundrymen and we trust their work will meet with your approval and adoption.

Very truly yours,

BENJAMIN D. FULLER, *Chairman for A. F. A.*
H. J. BOGGS, *Chairman for N. F. A.*

This letter was accompanied by a short historical resume of safety work by our association as follows:

July 27, 1920.

Mr. P. G. Agnew, Secretary.
American Engineering Standards Committee.
29 West Twenty-ninth Street.
New York, N. Y.

Dear Mr. Agnew:—

The subject of safety and sanitation has been actively discussed by the American Foundrymen's association for years. Committees of men prominent in the foundry business have worked out several codes which have been submitted to the body of the organization from time to time.

Thomas D. West, in an address to the American Foundrymen's association, assembled in convention in Pittsburgh, September, 1911, said, "At no period of the country's history has there been a greater number of reforms carried out than in the last decade: chief among these at present is the struggle to safeguard life and property against the results of accident."

The work of establishing a permanent safety code was given impetus at the convention of the American Foundrymen's association held in Chicago, September, 1914, when a number of valuable papers on the subject of "Safety" were presented, among which were papers by Magnus Alexander, A. W. Greg, G. F. Kent, T. Morril, Arthur T. Morrey, R. G. Williams and Thomas D. West.

A committee composed of the following men were appointed as a committee on safety and sanitation —

Victor T. Noonan, Industrial Commissioner of Ohio.
F. H. Elam, American Steel Founders of Chicago.
George B. Koch, Pennsylvania Railroad, Altoona, Pa.
E. B. Morgan, Worcester, Mass.
Richard Meidenke, Watertown, N. Y.
Thomas J. Scully, Sill Stove Works, Rochester, N. Y.
C. E. Pemberton, Pickands, Mather & Co., Cleveland.
Ralph West, West Steel Castings Co., Cleveland.

This committee brought a report before the convention of 1915, which embraced a code and led up to a discussion of the advisability of joining in the work of the then recently formed Board on "Safety and Sanitation" made up of members representing the National Founders' association, the Manufacturers' and National Metal Trades' association and the National Electrical Light association. The following year, or 1917, at the American Foundrymen's association convention held in Boston during the month of September the committee on safety and sanitation submitted a code which represented the work of the committee after discussion with representatives of the National Founders association. It was decided at this time to defer action on the adoption of the code until further deliberation by a representative

committee of three men each from the American Foundrymn's association and the National Founders' association in joint meeting.

Accordingly a meeting was held in Buffalo; the National Founders' association being represented by W. H. Barr, Lumen Bearing Co., Buffalo, N. Y.; H. J. Boggis, Taylor-Boggis Co., Cleveland, and A. F. Corbin, Union Mfg. Co., New Britain, Conn. The American Foundrymen's association by the president, B. D. Fuller; Ralph West, West Steel Castings Co., Cleveland, and Earl Morgan, Worcester, Mass.

This conference resulted in a code being drawn up which, after being submitted to the membership, was adopted by both the American Foundrymen's association and the National Founders' association.

Yours respectfully,
BENJAMIN D. FULLER, *Chairman.*
Committee on Safety, Sanitation and Fire Prevention,
American Foundrymen's Association.

The American Engineering Standards Committee acknowledged the receipt of communications and copy of code. The matter at present writing is before them for consideration.

The American Foundrymen's association is further participating in the work of uniform safety standardization, as witness the following letter under date of Aug. 2, 1920, to C. E. Hoyt, secretary.

Grinding Wheel Safety Code

As you no doubt know, there are a large number of safety codes and specifications in existence covering some of the more common hazards of industry. Some of the subjects are covered by a large number of such codes prepared by as many individuals and organizations and, as it is to be expected, these codes do not agree. Sometimes the discrepancies are so great as to seriously inconvenience the manufacturers and users of the products in question.

During the past two years a well organized movement has been under way to bring together the various interested parties to formulate a single safety code for each of these subjects which can be adopted as an American standard. This movement has now taken definite form and the American Engineering Standards Committee has been selected as the proper organization through which this work should be carried on. This is a very representative organization, composed of representatives of the five original national engineering societies, the United States bureau of standards and other associations of this kind.

This organization has asked the International Association of Industrial Accident Boards and Commissions and the Grinding Wheel Manufacturers of the United States and Canada, to act as joint sponsors for a safety code for the use of grinding wheels, which will be ultimately adopted as the American standard. A preliminary meeting of representatives of these two associations has already been held at which it was decided to add representatives of the following interests to our committee:

1. Users of large quantities of grinding wheels.
2. Grinding machine operators.
3. Federal government.

Your association was suggested as representing a number of users of large quantities of grinding wheels and we are asking you if you could appoint some one to serve on our committee. This representative should preferably be some one with a good, practical shop knowledge, especially in connection with grinding.

We do not expect that very much time will be required for work on this committee as, fortunately, there is not very much difference between the various grinding wheel codes now in use. Before submitting a draft to the American Engineering Standards Committee for approval, however, we wish to make sure that all interests concerned have been given an opportunity to express their opinions and ideas. Possibly only one general meeting of the committee will suffice.

Will you kindly give this consideration as promptly as possible and let us know if you can comply with our request?

Grinding Wheel Manufacturers' Association of the United States and Canada.

Safety Committee.
A. R. ROUSSEAU, *Chairman.*

AR-125-M.

In response to the request of the Grinding Wheel Manufacturers' association the American Foundrymen's association has appointed C. H. Gale, Pressed Steel Car Co., McKees Rocks, Pa., as representative, which appointment has been acknowledged through Mr. Rousseau, chairman, Grinding Wheel Manufacturers' association safety committee.

Respectfully submitted,
C. H. GALE,
R. H. WEST,
F. H. ELAM,
J. O. HOUZE,
VICTOR NOONAN,
BENJAMIN D. FULLER, *Chairman.*

High-Level Illumination as a Means of Increasing Foundry Production

By James Brakes Jr., Chicago.

During the last few years it has been hard to indict the foundry for its lack of progressiveness in the adoption of modern methods and labor saving devices. However, although a large number of foundrymen realize, and more are beginning to realize, the importance of adequate lighting facilities, still by far the majority are prone to be backward in this respect. Most foundries today have deplorable illuminating conditions, which tend toward restriction of output and are a menace to the vision and general health and in many cases a direct cause of accidents.

The following discussion of industrial lighting as applied to the foundry is presented in three parts: The requirements which must be fulfilled in the design of a satisfactory installation in a foundry; a discussion of proper reflecting equipment for the foundry; and proper illumination as an increase to foundry production.

Considered from the standpoint of safety to employes, 0.25 foot candle may in most instances be taken as the lower limit of permissible intensity of artificial light in a foundry. The upper limit of desirable intensity may be conservatively estimated at from 50 to 100-foot candles. Recommended intensities of foundry lighting as taken from the appendix to the proposed code of industrial lighting for the state of Ohio, 1919, are as follows:

	Intensity at the work in foot candles
Charging floor, tumbling, cleaning, pouring and shaking out	1 to 3
Rough molding, core making (rough)	2 to 6
Fine molding, core making (fine)	3 to 9
Average	3 to 6

The recommendations are naturally very conservative in view of their intended inclusion with a state enactment.

On a survey of industrial lighting conditions conducted by the Commonwealth Edison Co., it was found that the average lighting intensity of 18 foundries was 1.4-foot candles. The average foot candles recommended for immediate adoption in the above foundries was 6.6, including relatively idle or non-producing floor space. The attitude of the above foundries

FIG. 1 CANDLEPOWER CURVE OF A 500 WATT DEEP BOWL UNIT IN A CHICAGO FOUNDRY HAVING A COMMERCIAL MAINTENANCE SERVICE

toward better lighting was as follows: Progressive, 11; indifferent, 7; and antagonistic and indifferent, 1.

In 50 per cent of the above foundries the walls and lighting fixtures were dirt-covered, due to improper maintenance. This no doubt was partly due to the fact that the lights were hung over crowded floor space, or over the electric cranes where cleaning was difficult.

In order to secure the average recommended foot candles the foundryman or engineer must observe the character of the work done and decide the following: The color of the light; the type of lamps; and the location of lamps and selection of reflectors with reference to diffusion and direction of light and angle of vision, intrinsic brightness, accessibility, exposure of eyes to heat of lamp, dust shedding, mechanical strength, and the method of suspension of lighting units to minimize vibration.

The writer makes two distinct classifications with respect to character of work done.

1.—Work requiring maximum intensity of 9-foot candles, which includes:

CLEANING DEPARTMENT

Operations: Cleaning, finishing, assorting, repairing, mixing, and applying.

COREMAKING DEPARTMENT

Operations: Mixing sands, ramming, venting, re-enforcing, baking.

MACHINE MOLDING

Operations: Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing and pouring.

BENCH MOLDING

Operations: Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing and pouring.

ASSEMBLING

Operations: Lifting, setting cores, securing and pouring basins.

2.—Work requiring average intensity of 6.6 to 7-foot candles:

MELTING

Operations: Charging, firing, drawing and repairing.

POURING

Operations: Lining, baking, pouring and care of ladles.

CRANE FLOOR MOLDING

Operations: Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing and pouring.

LOAM MOLDING

Operations: Laying bricks, sweeping, finishing, baking, assembling, securing and pouring basins.

HEAT-TREATING AND ANNEALING

Operations: Charging, heating, drawing and repairing.

Candlepower in a certain direction gives no indication of the quantity of light generated. Therefore, it was necessary in illuminating practice to develop a unit whereby the quantity of total flux of light emitted by a source could be measured. The unit used is known as the "lumen" and light sources are now rated in total lumens and lumens per watt. Some of the ratings of modern type C or nitrogen-filled lamps are shown in Table I.

Table I

Watts	Approx. Lumens	Lumens per Watt
100	1260	12.6
150	2040	13.6
200	3100	15.5
300	4840	16.1
500	8750	17.5
750	13900	18.5
1000	19300	19.3

In addition to increasing the total lumens provided by the lamps, a still further increase must be made initially so that the depreciation of candlepower in the lamps by the collection of dust and dirt will not bring the average illumination, in service, below the value desired. Fig. 1 gives the candlepower curve of a 500-watt deep bowl unit, as taken from one of the Chicago foundries using a commercial maintenance service. Comparison is made in candlepower when the unit is clean as against the candlepower when the unit is dirty. This shows that the depreciation in effectiveness may be as high as 58 per cent. Under conditions most commonly found in foundries, which are by the way, extreme conditions on account of the dust and smoke, the depreciation in a two-week cleaning period may run as high as 50 per cent or greater.

The calculation of the total required light flux is made as follows.

$$\text{Total lumens to be generated} = \frac{\text{Ft. Cand. x Area in Sq. ft. x Depreciation Factor}}{\text{Coefficient of Utilization}}$$

In the case of a foundry the depreciation factor will run as high as 1.5 times the light output which would be required initially when the lighting units are new and clean. The coefficient of utilization is known as that proportion of the total

determined by traveling crane of 35 feet. Let the illumination called for be 9-foot candles. What equipment and wattage is called for?

Assume a semimonthly cleaning and an average combined lamp and fixture depreciation factor of 1.35. If we select the deep bowl porcelain enameled steel reflector we can figure on a utilization factor of 0.40 for this room.

$$\text{Total lumens to be generated} = \frac{9 \times 15{,}000 \times 1.35}{0.40} = 457{,}000$$

Now, referring to Table I, it is seen that this amount of flux would be given approximately by 24 1000-watt units, or 33 750-watt units, or 52 500-watt units. However, it is obvious that the uniformity of the illumination in the first two cases would be very poor.

On the other hand, to use 100 or 200-watt units would mean an abnormally close and expensive spacing. It may be said that in most cases 500-watt units for such a sized interior are found to be very satisfactory. Fifty-two 500-watt deep bowl units would therefore be recommended to be placed in four rows of 13 each, spaced approximately 14 feet apart in one direction and 18 feet apart, measured across the building.

In order to overcome the high depreciation factor, a Chicago firm has developed an easily cleaned 500-watt lighting unit, as shown in Figs. 2 and 3.

It is almost impossible to clean foundry lighting equipment every few days. The fixtures hang high and are inaccessible to the last degree. The work is dangerous, awkward, disagreeable and expensive to perform. In doing the work much dirt is dislodged and drops down on the molds, machines, and work beneath, hence restricting the work to certain hours, if at all. To meet this impossible situation, the fixture just mentioned has been designed. It compels the workman to clean his lighting fixture at least twice a day whether he wishes to do so or not. Lighting the fixture automatically cleans it. In turning the light out it does the same.

The cleaning device consists of two wiping blades, one that rotates against the interior, and one against the lamp bulb. As the stem switch is pulled, these two blades come into

action, sweeping the dirt off both lamp and reflector by a complete revolution. The blades never reverse. Such frequent cleaning never allows dirt to annoy workmen in dropping down on the work below. The tendency is rather for the finely divided dirt to float away. In the above described unit, a 500-watt bulb is used.

A glance at Fig. 2 shows that the unit is so constructed that it is very rigid and mechanically strong, thereby reducing vibration to a minimum. Any maintenance man can erect the fixture on present outlets without calling in an electrician.

Color of the Light

Under conditions which exist in a foundry, one criterion for the choice of an illuminant is the penetrating power of the light. The appearance of the sun through smoke, haze, or fog, evidences the fact that the shorter wave lengths, or the rays near the blue end of the spectrum, are absorbed or dispersed while the longer wave lengths pass through. Hence under such conditions, light in which red and yellow waves predominate, is the most effective and a clear-bulb lamp will give the best service.

Proper Illumination Increases Production

In a lighting survey of various factories in Chicago, it was found in some extreme instances that, due to lack of proper illumination, the time lost in handling equipment and doing work was as high as 30 per cent of the hours expended.

In order to show the saving resulting from an installation of high level lighting, and use for example, some such self-cleaning equipment as already referred to, let us assume that we might lower the 30 per cent payroll loss to 5 per cent. In a foundry of 20,000 square feet floor area, requiring 2 watts per square foot the necessary wattage would be 40,000, or 80 500-watt units. If the unit costs $25.00 as against an existing fixture cost of $10.00, the extra investment would be $1200.00. Such extra investment is good for fully five years. If 20 men are employed on this floor, at a wage of $10.00 per day, a $200 per day payroll is involved.

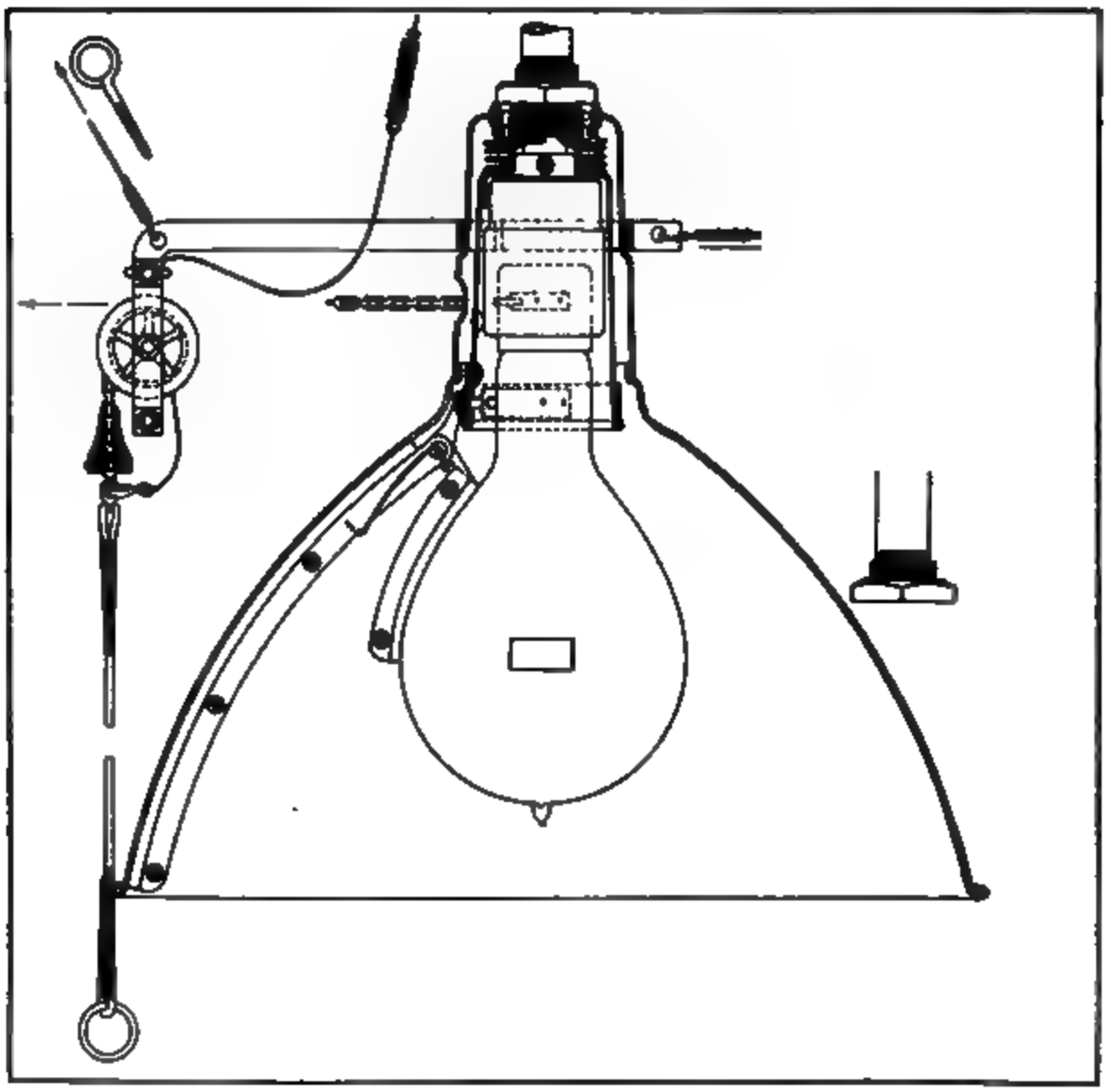

FIG 3- SECTIONAL DRAWING OF SELF CLEANING UNIT. PULL ON RING REVOLVES WIPING BLADES ON BULB AND REFLECTOR AND CLOSES OR OPENS LIGHTING CIRCUIT

Figuring on a 5 per cent pay loss in place of 30 per cent, we have indicated a payroll saving of $50.00 per day, $15,000 per year and $175,000 during life of equipment.

Why not let the illuminating engineer handle the problem? Give him a chance to rectify the many abuses and many conditions that are detrimental, that at present are existing and will exist from the mere fact that foundrymen have no intention of changing them. Call in the illuminating engineer who is employed by the central station.

The central station engineer regulates competition, selects suitable equipment, and dwells not only on the importance of fixture design but on illuminating results. He

will have something to say about the disposition of outlets, and will be able to advise with his precise knowledge of the laws of light, a minimum of outlets in a foundry to secure the maximum productive effort.

The author realizes the situation of the foundrymen with their forces of men who have to be provided with work, and that they are forced to take jobs and complete them at a profit. With this fact in mind, they may sometimes operate contrary to their intentions. But with the foundryman's co-operation we will master the present situation, which will be one of the many steps toward increased production. The writer wishes to extend his thanks to E. D. Tilson, of the Commonwealth Edison Co. for help in preparing this paper.

"The One Best Way to Do Work" in the Foundry

By FRANK B. GILBRETH and L. M. GILBRETH, Montclair, N. J.

This paper presents a method of increasing efficiency in foundries.

The "One Best Way to Do Work" is a phrase that summarizes this method. The best available way of performing the work is discovered, installed and maintained, and through this process, production is increased without waste of either the human or material element.

The discovery and use of the "one best way" is no departure from the procedure of "scientific management." It determines what methods scientific management shall standardize and maintain. It implies not only the intensive study of the material element, in which the metal industry has excelled, but a similar study of the human element. This study supplements the findings of those in the industry with the investigations of educators, psychologists, physiologists and psychiatrists outside industry. Installing and maintaining the results of the investigations requires the use of the entire mechanism of management, with an emphasis on supplying the necessary incentive and reward, if that durable satisfaction is to result which keeps the entire process in operation.

Best Way Revealed by Motion Study

The "one best way" is discovered through motion study and fatigue study. "Better ways" of doing work, or ways that appear better, may be discovered by more or less careful observations, but if the "best" way is to be found and the improvement is to be measured and maintained, motion study and fatigue study *must* be used. Without these, a method may be thought to be better, which is really no improvement, or a method which really is better may be tried and rejected because the proofs of its excellence are not at hand.

The user of a method is almost never able to judge of

its fatigue as compared with another method. For this reason, among others, he may declare one method better than another when measurement would show it much less efficient. Again, a method that is really better may be rejected during the period of learning and first use. The interference of old habits will render the results so unsatisfactory to the user as well as from the production standpoint that the method is likely to be discarded without being used until it becomes a habit and produces satisfaction to the user and uniformity to the product. The "one best way" provides for measurement and maintenance until it has demonstrated its superiority.

Plan Provides for Cumulative Improvement

It also provides for continuous and cumulative improvement. We hear much in these days of the necessity of "stimulating invention," of "extending an opportunity for the creative spirit," etc. These *must* be provided for. Under this plan, they are provided for through the mechanism of the suggestion system, which has an important part in the development of the "one best way," and which never performs its highest functions except in connection with the "one best way."

The "one best way" to do work, then, supplies an aim for efficiency, a summary of its results and a method for its evolution.

It is scarcely necessary to point out why this "one best way" is urged in foundry work. We have seen, as yet, no foundry that does not offer opportunities for savings. We have seen, as yet, no foundry that has derived the "one best way" and is using it, or that is undertaking such derivation. The foundry is a most important industrial factor. It deals with vital elements of material prosperity and still more vital elements of human prosperity. It has shown itself a fertile field for investigations.

Find Foundry Jobs for Blind

In our work of discovering occupations for the handicapped, we investigated foundry operations in co-operation with the Red Cross Institute for the Blind. We found there craft skill and diversity of operations—an ideal field for motion

and fatigue economy. We were able to discover certain processes fitted for blinded workers, and also to make a survey which showed the foundry to be a field for standardizing processes and increasing output enormous in its possibilities.

The day must come when every foundry will undertake to standardize, yes, super-standardize, its processes. Results will come quickest if, instead of undertaking the work separately, the foundries combine, through this association, to establish a laboratory and to make the fundamental investigations for the entire industry. You know that apprenticeship methods are medieval; and that work methods are unstandardized, inefficient and wasteful! You know that craft knowledge, craft skill, and engineering knowledge are not conserved and transferred in the industry as they might be.

"One Best Way" Leads to Success

The "one best way" to do work has proved itself an efficient method wherever it has been scientifically and persistently applied. It has demonstrated itself as successful in many diversified activities, including those of the foundry. It does not do away with or depreciate, or underestimate the results of past successes or individual achievements. It does not entail introducing strange and alien factors into foundry development. It is a method applicable by any who desire to use it, and who are willing to learn to use it. It not only *must be* used, ultimately, for permanent success; you *have* used it, unknowingly perhaps, wherever you have been successful. You will gain most and quickest by using it scientifically.

Measure and record what you do. Study your records. Determine the most efficient method. Note opportunities for improvement. Improve wherever possible. Lay out lines for further improvement. Install and maintain conditions which insure the best available method being practiced, taught and improved as opportunities offer. Do all this scientifically. This is the outline of the method involved by the "One Best Way to Do Work." This method is applicable to the foundry. It remains for you to decide *when*, *where* and *how far* it shall be applied, and your decisions will influence not only your own industry but national and international prosperity.

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